

# Naval Research Laboratory

Stennis Space Center, MS 39529-5004

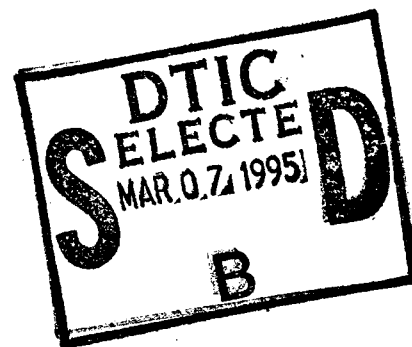


NRL/MR/7441--94-7097

## Digital Mapping, Charting, and Geodesy Analysis Program Technical Review: Digital Nautical Chart Product 1

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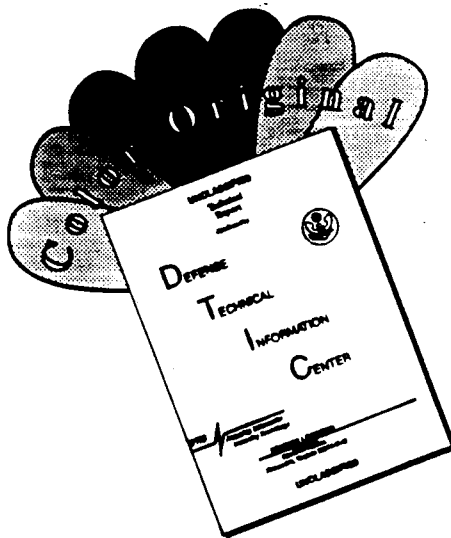
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<b>1. AGENCY USE ONLY</b> <i>(Leave blank)</i>		<b>2. REPORT DATE</b> December 9, 1994	<b>3. REPORT TYPE AND DATES COVERED</b> Final	
<b>4. TITLE AND SUBTITLE</b> Digital Mapping, Charting, and Geodesy Analysis Program Technical Review: Digital Nautical Chart Product 1			<b>5. FUNDING NUMBERS</b> Job Order No. 5745137A5 Program Element No. 0603704N Project No. R1987 Task No. 300 Accession No. DN257086	
<b>6. AUTHOR(S)</b> LTJG Steven Kuder, Kevin Shaw, Vincent Miller*, Danette Coughlan, Julian Richard, and Susan Carter				
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Naval Research Laboratory Marine Geosciences Division Stennis Space Center, MS 39529-5004			<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b> NRL/MR/7441--94-7097	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Naval Research Laboratory Tactical Oceanographic Warfare Support Office Stennis Space Center, MS 39529-5004			<b>10. SPONSORING/MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b> *Mississippi State University				
<b>12a. DISTRIBUTION/AVAILABILITY STATEMENT</b> Approved for public release; distribution unlimited.			<b>12b. DISTRIBUTION CODE</b>	
<b>13. ABSTRACT</b> <i>(Maximum 200 words)</i> The first production release of the Digital Nautical Chart (DNC) was a significant improvement over the previous prototypes. However, several key areas are still either incomplete or not addressed in the DNC. The Environment thematic layer still is not present in the DNC and environment data from the paper charts is omitted. DNC accuracies are not clearly stated. Feature labels do not follow the feature they describe, as on the paper charts. There is no standard symbology for the DNC, but there is one for the paper charts. The method of updating and correcting the DNC is not discussed. In addition, data errors between the product specification and the actual database are noted. Issues raised by reviews of DNC prototypes 2 and 3, but not yet addressed, are restated.				
<b>14. SUBJECT TERMS</b> requirements, MC&G data, mapping, DCW, ADRG, WVS			<b>15. NUMBER OF PAGES</b> 25	
			<b>16. PRICE CODE</b>	
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified	<b>20. LIMITATION OF ABSTRACT</b> SAR	

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# DIGITAL MAPPING, CHARTING, AND GEODESY ANALYSIS PROGRAM TECHNICAL REVIEW: DIGITAL NAUTICAL CHART PRODUCT 1

## 1.0 INTRODUCTION

Digital Nautical Chart (DNC) Product 1 is the first release of the DNC in production form. The purpose of the DNC is to be a primary component of the Navigation Sensor System Interface by replacing the paper charts currently used on Navy and Coast Guard ships, and to support Geographic Information System (GIS) applications. The goal of this release was to receive evaluation comments from operational units at sea. The DNC will provide navigational quality nautical chart information in digital form for exploitation by the entire spectrum of Navy and Marine Corps users. Also, this product will be a base to add supplemental layers of warfare-specific information and tactical decision aids.

The DNC is written according to the Defense Mapping Agency's (DMA) Vector Product Format (VPF) (MIL-STD-2407) and DMA's Product Specifications for *Digital Nautical Chart*, Second Edition, 26 August 1993 (PS/2GC/040) [1].

## 2.0 DNC CONTENTS

### 2.1 Libraries

The area covered by DNC Product 1 is divided into five libraries extending from Cape May, New Jersey, to Cape Lookout, North Carolina. They are the Browse, General, Harbor, Approach, and Coastal libraries. The Browse library depicts the location and extent of the DNC database on a particular CD-ROM on a global map, and is intended to be used for reference. The General library is a digitization of paper nautical charts with scales on the order of 1:500,000, and is a broad overview of the entire area contained in the database. The Coastal library originates from paper charts with scales ranging from 1:75,000 to 1:500,000, and is used for coastal navigation. The Approach library is digitized from nautical charts with scales of 1:25,000 to 1:100,000, and is used for near-shore areas and harbor approaches. The Harbor library is digitized from charts with scales of 1:50,000 or less, and serves as a detailed navigational guide for harbors and inland waterway areas.

### 2.2 Thematic Layers

As per the DNC product specifications, the General, Harbor, Approach, and Coastal libraries each contain 12 thematic layers:

- Cultural Landmarks
- Earth Cover
- Environment
- Hydrography
- Inland Waterways
- Land Cover
- Limits
- Aids to Navigation
- Obstructions
- Port Facilities
- Relief
- Data Quality

The Browse library contains two thematic layers:

- Coastline/Countries
- Library Boundaries

Each layer serves as the header for a grouping of the information printed on the original paper nautical charts.

### 3.0 FINDINGS AND RECOMMENDATIONS

#### 3.1 Environment Layer

The Environment layer has been missing from every library in the previous prototypes and in the current DNC product. According to the product specification, this layer should contain data concerning currents, tides, and magnetic anomalies of significance to navigation. Such data does exist on the paper charts.

Compass roses (Fig. 1) are used to give information on magnetic variation for the areas in which they are placed. They tell the measure and direction of the variation, the year in which this measurement was made, and the expected annual increase in the variation. This data could easily be represented in the DNC with the creation of a new point feature (i.e., "Magnetic Variation") with three attributes containing the data mentioned above.

Related to the compass roses, there are also on chart 12200 lines of magnetic variation (Fig. 2). These are lines of constant variation giving the amount and direction of the variation and the year the variation was measured. These could be readily represented as line features.

In addition, on chart 12200, there are "Local Magnetic Disturbance" areas east of Cape Hatteras, east of Currituck Sound, and east of Cape Henry. This feature is currently accounted for in the product specification. The problem in placing these areas in the DNC is that they are merely text items with no definite regions shown on the paper chart. This problem could be solved by likewise placing the text in the same region in the DNC. However, this brings into play the issue of text in the DNC not following the feature it describes (see 3.5 Text).

Another type of environmental data contained on the paper charts, which is not contained in the DNC, is tidal data. All of the paper charts in the Harbor and Approach libraries contain "Tidal Information" tables for certain points on the chart (Fig. 3). This information should be included with the feature "BG030 Tide Data Point" by adding the following attributes:

- Reference Datum
- Height at Mean Higher High Water
- Height at Mean High Water
- Height at Mean Low Water
- Height at Extreme Low Water

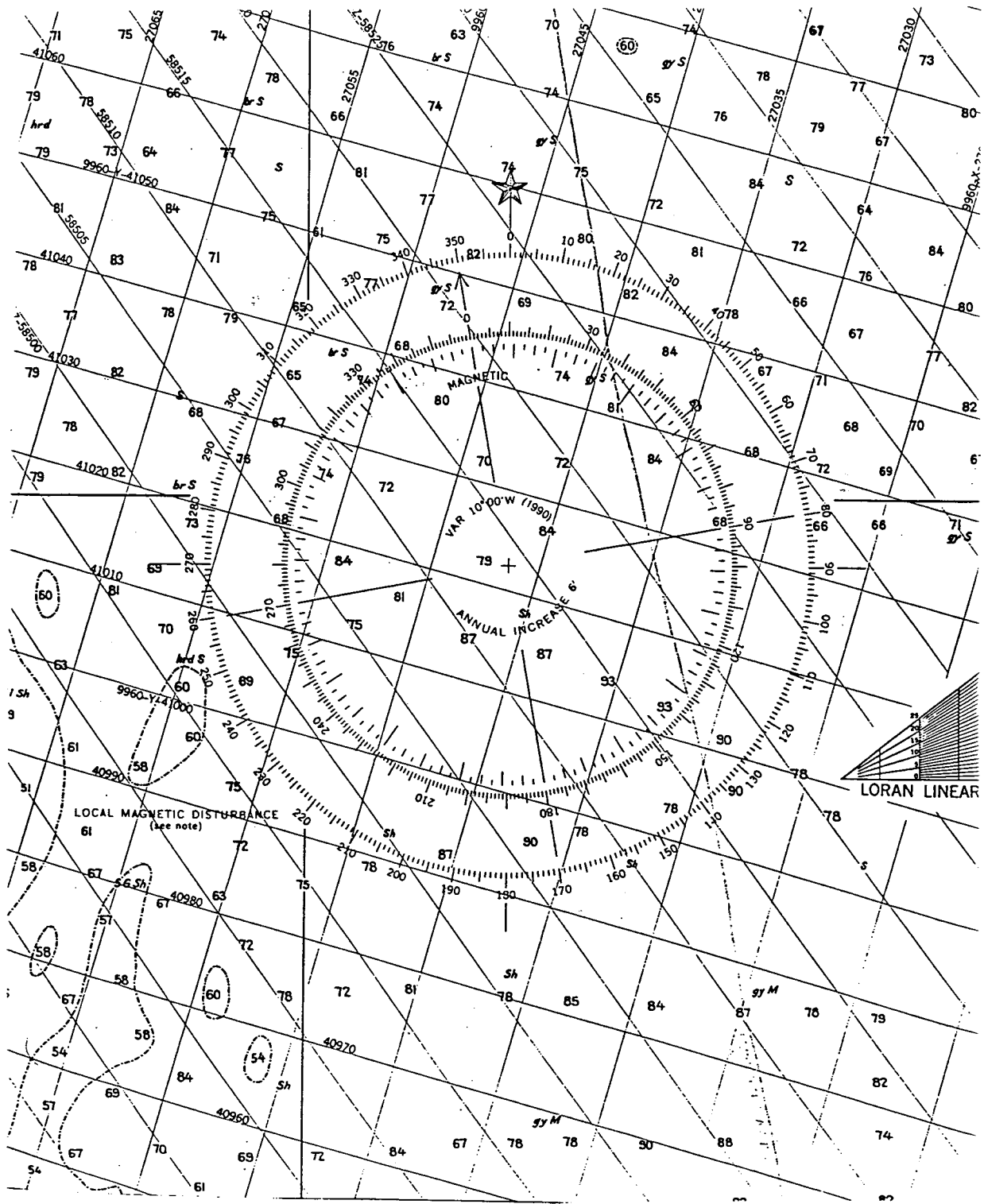


Fig. 1 — Compass rose from DNC chart 12245

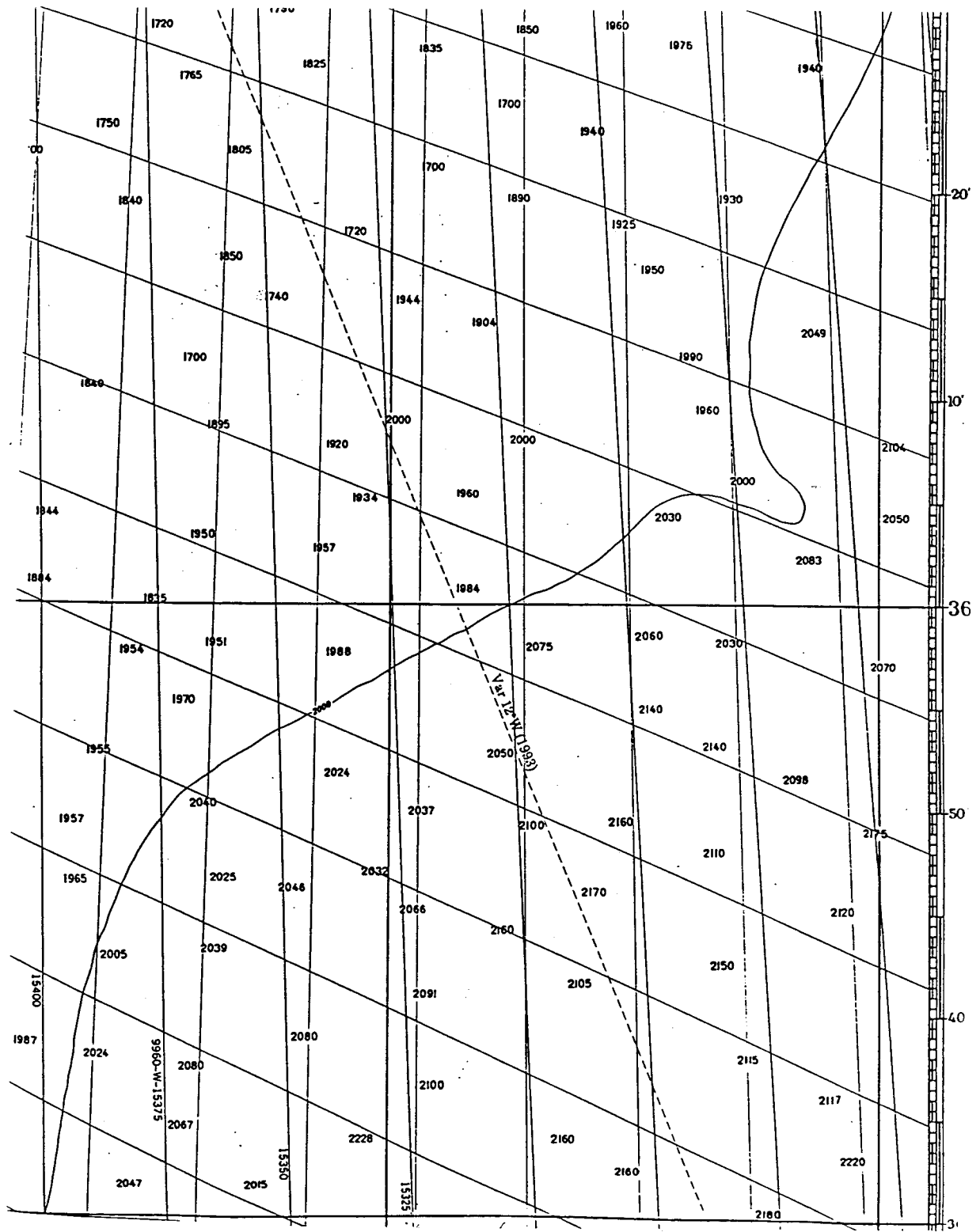


Fig. 2 — Magnetic variation lines from DNC chart 12200

TIDAL INFORMATION

Place		Heights referred to datum of soundings (MLLW)			
Name	(Lat/Long)	Mean Higher High Water	Mean High Water	Mean Low Water	Extreme Low Water
Little Creek	(36°55'N/76°11'W)	feet 2.9	feet 2.7	feet 0.1	feet -3.0
Lynnhaven Inlet, Highway Bridge	(36°54'N/76°05'W)	2.3	2.1	0.1	-3.0
Cape Henry	(36°56'N/76°00'W)	3.1	2.9	0.1	-3.0

(389)

Fig. 3 — Tidal information table from DNC chart 12245

Each of these recommendations for changes or additions to the Environment layer have been made in previous Digital Mapping, Charting, and Geodesy Analysis Program (DMAP) reviews of the DNC.

### 3.2 Accuracy

According to the DNC product specification, absolute horizontal and vertical accuracies are given for different numbered classes of features. As was noted in earlier DMAP reviews of DNC prototypes, the reader cannot readily determine which DNC features fall into which class because there are no class definitions or assignment of class numbers to features. Knowing the accuracies for these classes without knowing which features are in the classes does not convey any information. A listing of classes and the DNC features within them should be stated along with the absolute accuracies.

### 3.3 Modeling and Simulation Requirements for the DNC

Table 1 contains the current requirements not met by the DNC when compared with a 1993 Navy and Marine Corps survey conducted by DMAP for the Defense Modeling and Simulation Office. Two areas of the survey asked Navy and Marine Corps programs which digital products they currently used or planned to use, and in certain feature classes what features did they require. Combined, these two questions give the features required by current and future DNC users. Table 1 gives the features not met by the DNC. The "Feature Class" is the class name used in the survey, but the corresponding DNC class or thematic layer is given in parenthesis.

### 3.4 Database Naming

The method for naming each DNC database is described as "DNCXX" where "XX" represents a geographically determined disc number. This implies that the globe is divided into numbered regions with each region represented by a different DNC database and CD-ROM. To serve as a reference for the different DNC databases, a figure depicting each numbered region on the globe should be included in the product specification and added to the Browse library as an additional thematic coverage.

### 3.5 Text

As mentioned in previous DMAP reviews of the DNC, text would be more descriptive if it followed the feature that it describes. Figures 4 and 5 represent labeling on the original paper chart

Table 1 — Current Requirements not Met by the DNC

Feature Class (DNC Feature Class)	Feature
Hydrography	Water Tower, Maritime Station, Crib, Penstock, Current/Flow Arrow
Transportation (Cultural Landmarks)	Snow/Rock Shed, Trail, Cart Track, Culvert, RR Turntable
Vegetation (Land Cover)	Cropland, Grassland, Bog
Populated Place (Cultural Landmarks)	Plaza/City Square, Shanty Town, Tent Dwelling, Campground/Campsite, Ski Jump, Swimming Pool
Industry (Cultural Landmarks)	Flume, Cistern, Blast Furnace, Cooling Tower, Catalytic Cracker, Feedlot/Stockyard/Holding Pen, Filtration/Aeration Bed
Soil (Land Cover)	Peat, Evaporites, Rock Outcrops
Physiographic (Land Cover)	Bluff/Cliff/Escarpment, Glacial Moraine, Asphalt Lake, Salt Pan, Esker, Fault, Geothermal Feature, Ice Cliff, Pack Ice, Polar Ice, Sabkha
Utility (Cultural Landmarks)	Underground Pipeline, Solar Panel
Boundary (Earth Cover)	Boundary Marker, Cease-Fire Line, Control Point

and in the DNC, respectively. As can be seen by comparing the two figures, the label in Fig. 4 follows the feature, but in Fig. 5 the label is almost perpendicular to the feature. This could cause obvious confusion.

### 3.6 International Standardization Agreements

Paragraph 6.5.4 states that International Mapping, Charting, and Geodesy Agreements are not applicable to the DNC. This seems incorrect because the DNC uses the feature attribute coding catalog (FACC) feature coding scheme, which is a product of the Digital Geographic Information Exchange Standard, an international organization.

### 3.7 Interchart Inconsistencies

The following interchart inconsistencies are mentioned because they are readily noticed in the DNC, but are not addressed in the product specification. A section explaining possible inconsistencies should be included in the specification as a courtesy to the user.

In several instances, where charts of different scales in the same library meet, an unexplained change in the data occurs. This change is especially true in the Harbor library since the library consists of three different charts with two different scales. As an example, Built-up Areas on chart 12222 (1:40,000) abruptly ends where chart 12245 (1:20,000) begins (Fig. 6). Chart 12245 has no Built-up Areas, but instead shows a dense network of streets. A similar situation occurs in Fig. 6 with Soundings in the Hydrography layer. There is a noticeable line across Chesapeake Bay where the low density of soundings on chart 12222 suddenly ends and the higher sounding density on charts 12245 and 12254 begins (both 1:20,000).

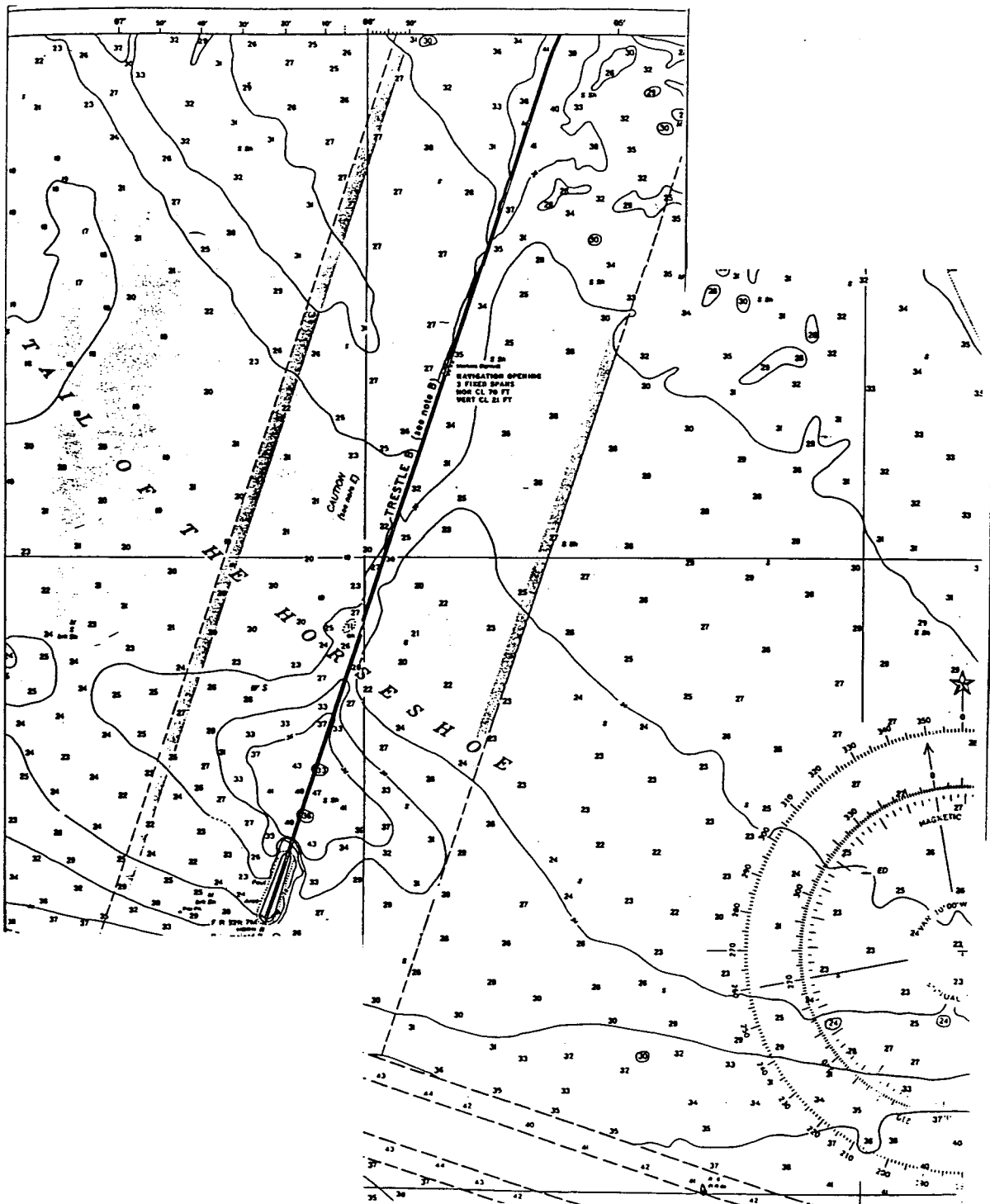


Fig. 4 — Labeling of paper chart features

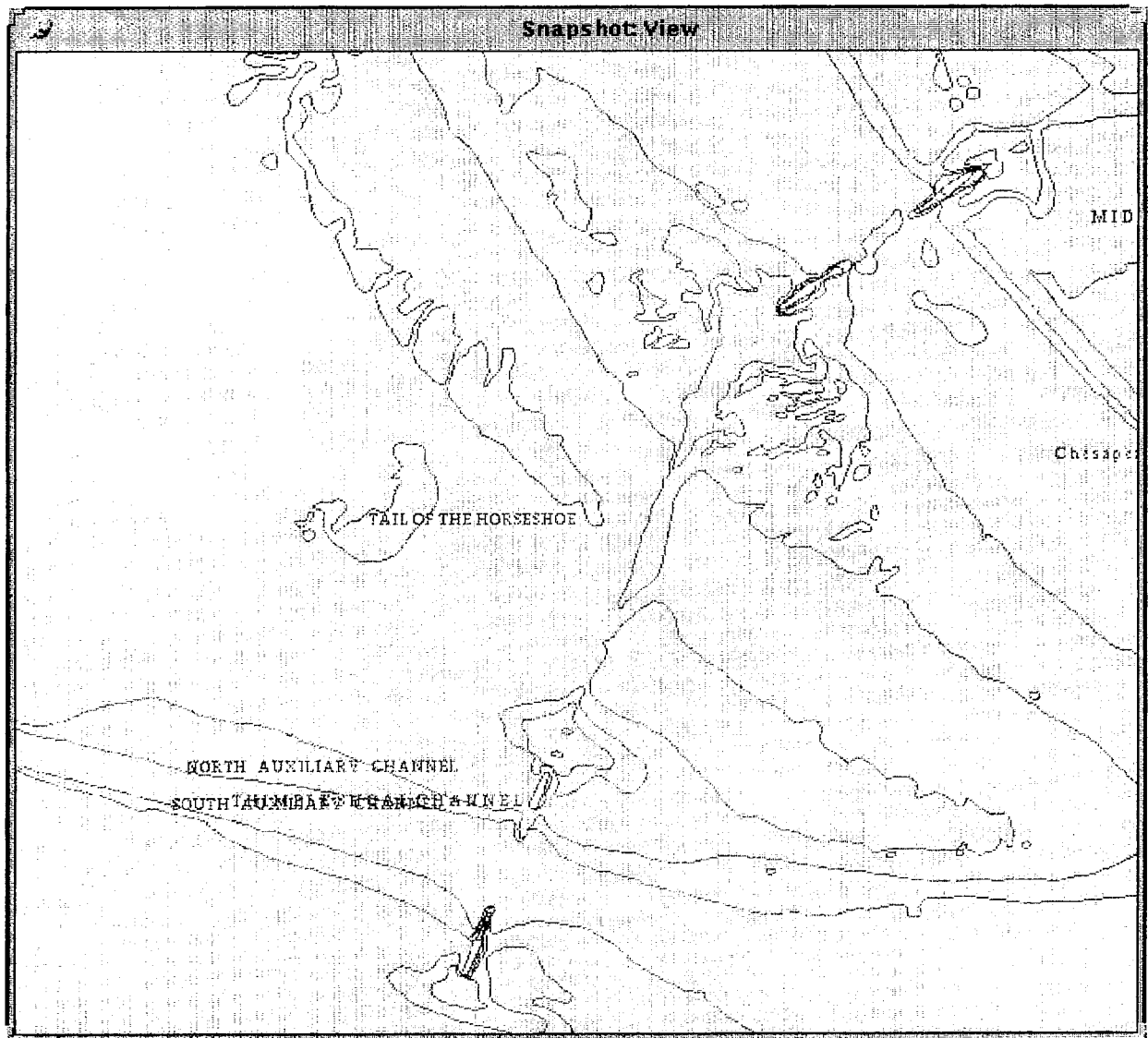


Fig. 5 — Labeling of DNC features

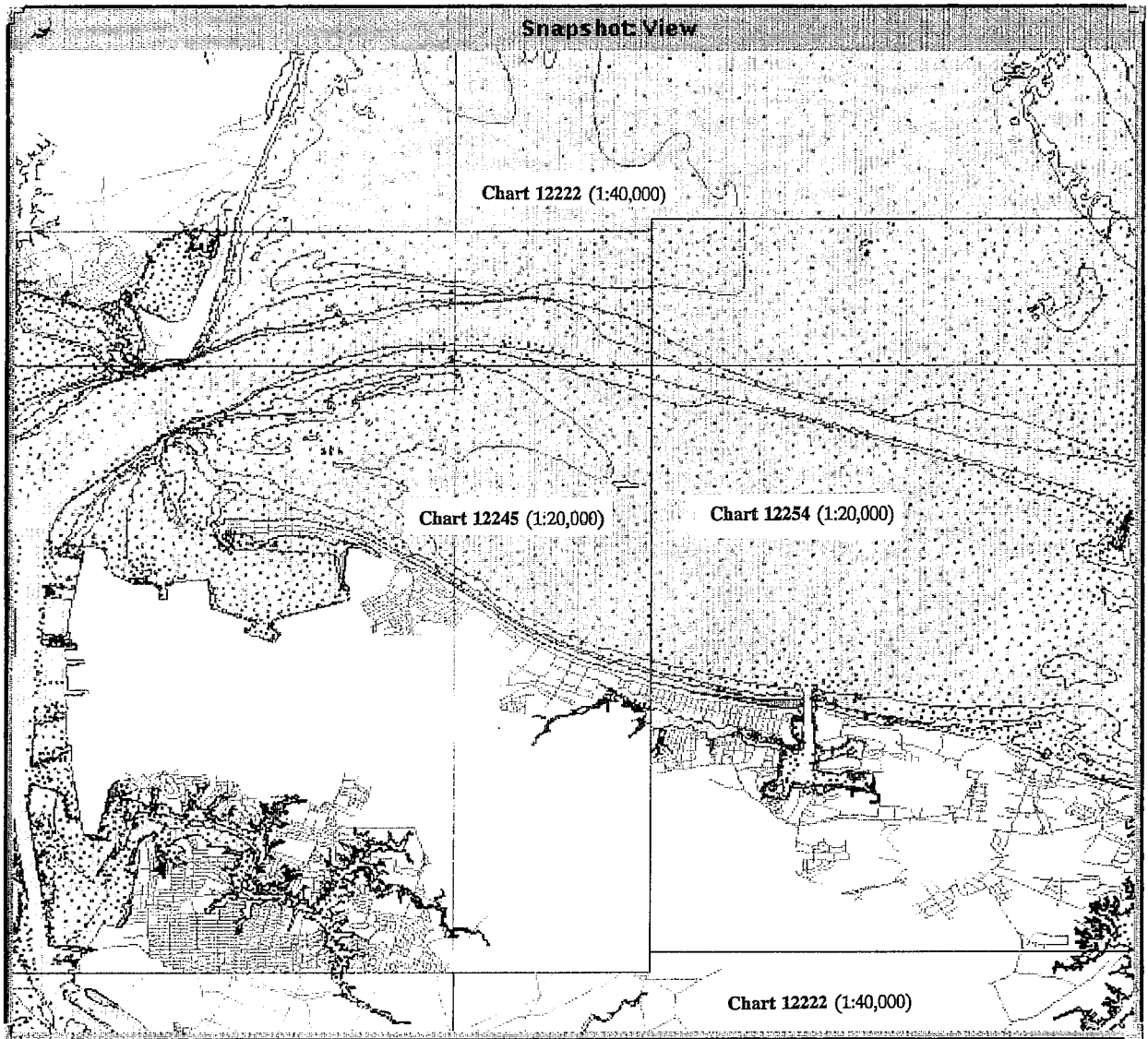


Fig. 6 — Interchart inconsistencies due to different DNC chart scales in the Harbor library

In the Harbor library, the 24-ft Depth Curve line is missing. The depth curve interval is 6 ft, but for some reason the 24-ft line is missing from paper charts 12222 and 12254. It is contained on chart 12245. To compensate for this, the 24-ft curve has mostly been removed from the digitized version of chart 12254 except for closed 24-ft contours. Comparison of Figs. 5 and 6 demonstrates this problem. Note that the DNC does not include text for contours. A spatial query would be required to obtain the contour value.

A more significant problem is where the Depth Curve areas of DNC Tiles 5 and 6 meet south of Willoughby Bank. Here a small portion of a larger Depth Curve area is contained on Tile 5 with the rest of the area on Tile 6 (Fig. 7). Both portions are entered into the DNC database with different Contour Value High attributes, causing them to graphically appear as two separate Depth Curve areas instead of one.

### 3.8 Channel Depths

All of the charts in the Harbor library contain tabular data for channel depths that are not included in the DNC (Fig. 8). The best place for this data would be under the Limits layer under the feature Route (Maritime). Attributes would need to be added for the Left Outside Quarter, Left Inside Quarter, Right Inside Quarter, Right Outside Quarter, Date of Survey, Width, Length, Depth, and Reference Datum. The data could then be added for each channel in the table.

### 3.9 Symbology

The product specification states that symbology is a function of the software used to display the DNC. DMAP has previously recommended that the standard set of symbology contained in DMA Chart No. 1 and used on paper nautical charts, should be adopted as the standard symbology set for the DNC. The symbology set should be included on every DNC CD-ROM.

### 3.10 Future Digitizations and Updates to the DNC

The process for producing the DNC is adequately described in the product specification. However, there is no mention of how future DNC databases will be produced or updated.

### 3.11 Product Specification

The appendix portion of the DNC specification contains detailed definitions and tables for each thematic layer. Because this appendix is so large, it should be indexed or include a table of contents in order to make the information more accessible.

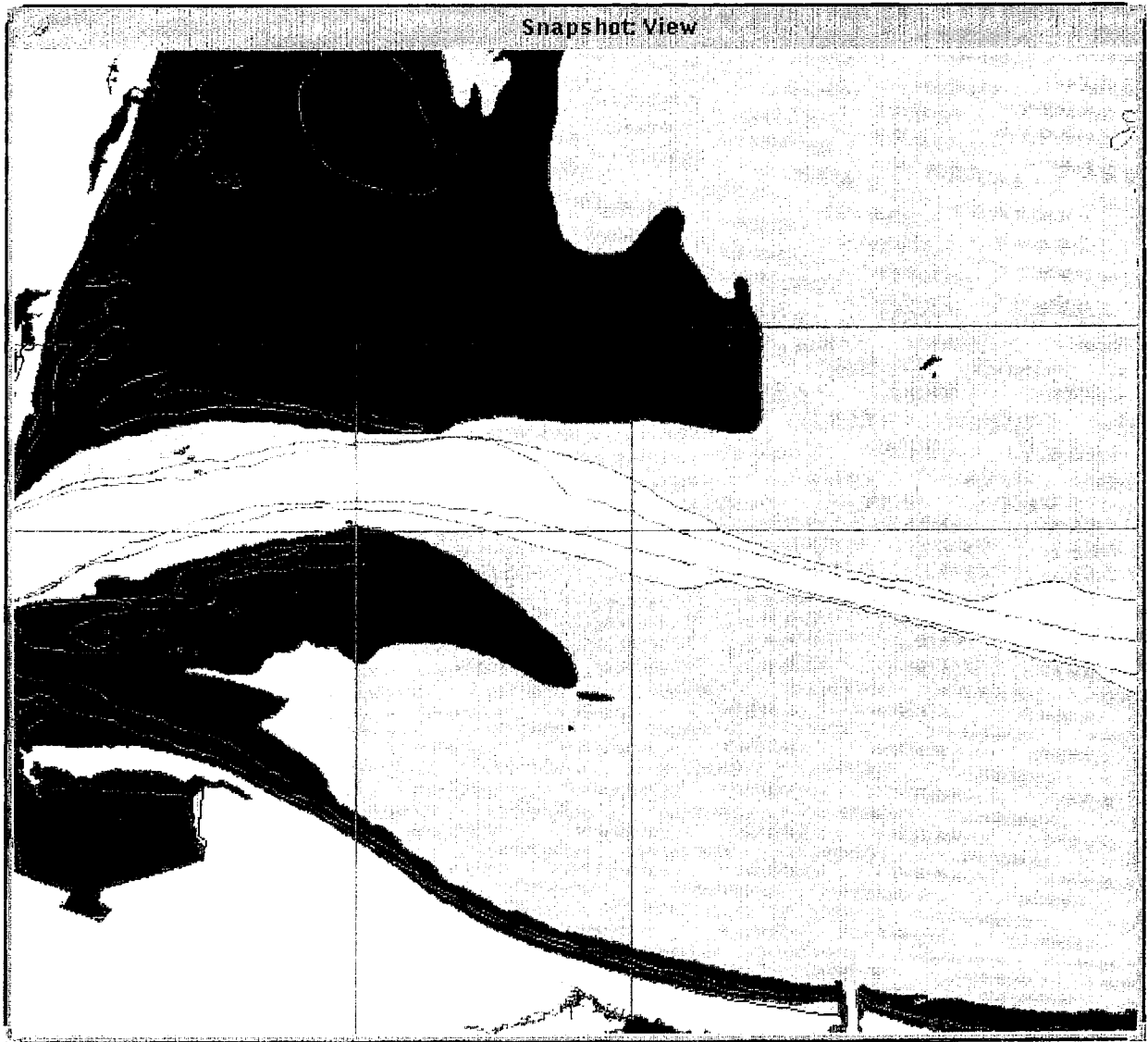


Fig. 7 — Depth contour areas in DNC Harbor library

THIMBLE SHOAL CHANNEL DEPTHS								
TABULATED FROM SURVEYS BY THE CORPS OF ENGINEERS - REPORT OF OCT 1989								
CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOWER LOW WATER (MLLW)						PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	LEFT INSIDE QUARTER	RIGHT INSIDE QUARTER	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH (NAUT. MILES)	DEPTH MLLW (FEET)
THIMBLE SHOAL CHANNEL A	47.5	45.8	45.8	45.0	8,9-89	1000	13.0	55
<p>A. THE CHANNEL IS RESTRICTED TO EXCLUDE VESSELS AND TOWS DRAWING LESS THAN 25 FEET. THERE IS NO RESTRICTION TO PASSENGER SHIPS.</p> <p>NOTE - CONSULT THE CORPS OF ENGINEERS FOR CHANGES SUBSEQUENT TO THE ABOVE INFORMATION</p>								

Fig. 8 — Channel depth table from DNC chart 12245

#### 4.0 DATA ERRORS

The following section updates those DNC Prototype 3 items that have not been addressed in the DNC Product 1. The same numbering is used. New (or rather previously undiscovered) items are italicized.

##### 4.1 Library: AXX08280

##### 1. 30.2.1.a (Cultural Landmarks Coverage)

AF010 (Chimney/Smokestack) [point feature]

contains NAM (Name) attribute which is not described in the spec.

*contains COL (Character of Light) attribute which is not described in the spec.*

AM070 (Tank) [point feature]

contains NAM (Name) attribute which is not described in the spec.

AN010 (Railroad) [line feature]

missing attribute LOC (Location Category)

missing attribute VRR (Vertical Reference Category)

Landmark point, clock tower, at (36d 57m 2.6s, -76d 18m 45.4s) cannot be defined properly in the data, due to the constraints of the spec.

##### 5. 30.2.8.a (Aids to Navigation Coverage)

BC010 (Beacon) [point feature]

contains COL (Character of Light) attribute which is not described in the spec.

contains PER (Period of Light) attribute which is not described in the spec.

##### 6. 30.2.9.a (Obstructions Coverage)

BD000 (Underwater Danger/Underwater Hazard) [point feature]

contains HDH (Hydrographic Drying Height) attribute which is not described in the spec.

contains NAM (Name) attribute which is not described in the spec.

BD100 (Pile/Piling/Post) [point feature]  
contains HDP (Hydrographic Depth) attribute which is not described  
in the spec.

BD180 (Wreck) [point feature]  
contains HDH (Hydrographic Drying Height) attribute which is not  
described in the spec.  
contains NAM (Name) attribute which is not described in the spec.  
contains TXT (Text Attribute) attribute which is not described in  
the spec.

7. 30.2.10.a (Port Facilities Coverage)  
BB190 (Pier/Wharf/Quay) [line feature]  
missing attribute NAM (Name)

#### 4.2 Library: COASTAL

9. 30.2.1.a (Cultural Landmarks Coverage)  
AL015 (Building) [point feature]  
missing attribute SST (Sound Signal Type)  
missing STA (Station Type Category (Maritime))

AM070 (Tank) [point feature]  
contains NAM (Name) attribute which is not described in the spec.

AN010 (Railroad) [line feature]  
missing attribute LOC (Location Category)  
missing attribute VRR (Vertical Reference Category)

14. 30.2.8.a (Aids to Navigation Coverage)  
BC010 (Beacon) [point feature]  
contains COL (Character of Light) attribute which is not described  
in the spec.  
contains MLR (Multiple Light Ranges) attribute which is not  
described in the spec.  
contains PER (Period of Light) attribute which is not described in  
the spec.

15. 30.2.9.a (Obstructions Coverage)  
AQ040 (Bridge/Overpass/Viaduct) [line feature]  
missing attribute NAM (Name)  
missing attribute TUC (Transportation Use Category)  
BD000 (Underwater Danger/Underwater Hazard) [point feature]  
contains HDH (Hydrographic Drying Height) attribute which is not  
described in the spec.  
contains NAM (Name) attribute which is not described in the spec.  
BD100 (Pile/Piling/Post) [point feature]  
contains HDP (Hydrographic Depth) attribute which is not described  
in the spec.

BD180 (Wreck) [point feature]  
missing attribute COD (certainty of Delineation)  
contains HDH (Hydrographic Drying Height) attribute which is not described in the spec.  
contains NAM (Name) attribute which is not described in the spec.  
contains TXT (Text Attribute) attribute which is not described in the spec.

16. 30.2.10.a (Port Facilities)  
BB190 (Pier/Wharf/Quay) [line feature]  
missing attribute NAM (Name)

#### 4.3 Library: GENERAL

19. 30.2.5.a (Inland Waterways Coverage)  
BH210 (Inland Shoreline) [line feature]  
contains NAM (Name) attribute which is not described in the spec.

21. 30.2.8.a (Aids to Navigation Coverage)  
BC010 (Beacon) [point feature]  
missing attribute CCC (Color Code Category)  
contains COL (Character of Light) which is not described in the spec.  
contains MLR (Multiple Light Ranges) which is not described in the spec.  
contains PER (Period of Light) which is not described in spec.  
missing attribute REF (Radar Reflector Attribute)  
missing attribute SST (Sound Signal Type)  
missing attribute TMC (Top Mark Characteristic)

BC020 (Buoy) [point feature]  
missing attribute CCC (Color Code Category)  
missing attribute EOL (Elevation of Light)  
\* missing attribute LVN (Light Range, Nominal) (some)  
missing attribute REF (Radar Reflector Attribute)  
missing attribute SST (Sound Signal Type)  
missing attribute TMC (Top Mark Characteristic)

\* -- indicates that some of the points are missing LVN, and others have it misnamed

BC040 (Light) [point feature]  
missing attribute CCC (Color Code Category)  
missing attribute EOL (Elevation of Light)  
missing attribute IAC (IALA Aid Category)  
missing attribute REF (Radar Reflector Attribute)  
missing attribute SST (Sound Signal Type)  
missing attribute TMC (Top Mark Characteristic)

22. 30.2.9.a (Obstructions Coverage)  
AQ040 (Bridge/Overpass/Viaduct) [line feature]

missing attribute NAM (Name)  
missing attribute TUC (Transportation Use Category)

BD180 (Wreck) [point feature]  
missing attribute COD (Certainty of Delineation)  
contains HDH (Hydrographic Drying Height) attribute which is not  
described in the spec.  
contains TXT (Text Attribute) which is not described in the spec.

#### 4.4 Library: HXX08280

30. 30.2.1.a (Cultural Landmarks Coverage)  
AM070 (Tank) [area feature]  
contains NAM (Name) attribute which is not described in the spec.

AM070 (Tank) [point feature]  
contains NAM (Name) attribute which is not described in the spec.

32. 30.2.5.a (Inland Waterways Coverage)  
BH210 (Inland Shoreline) [line feature]  
contains NAM (Name) attribute which is not described in the spec.

33. 30.2.7.a (Limits Coverage)  
BB010 (Anchorage) [area feature]  
contains TXT (Text Attribute) attribute which is not described in  
the spec.

BB010 (Anchorage) [line feature]  
contains BRG (Bearing of Object) attribute which is not described in  
the spec.  
contains DRP (Description of Reference Point) attribute which is not  
described in the spec.  
contains MBL (Maritime Boundary Limit) attribute which is not  
described in the spec.  
contains TXT (Text Attribute) attribute which is not described in  
the spec.

34. 30.2.8.a (Aids to Navigation Coverage)  
BC010 (Beacon) [point feature]  
contains COL (Character of Light) attribute which is not described  
in the spec.  
contains MLR (Multiple Light Ranges) attribute which is not  
described in the spec.  
*contains PER (Period of Light) which is not described in spec.*

BC020 (Buoy) [point feature]  
missing attribute EOL (Elevation of Light)  
missing attribute LVN (Light Range, Nominal)

35. 30.2.9.a (Obstructions Coverage)  
BD000 (Underwater Danger/Underwater Hazard) [point feature]

contains HDH (Hydrographic Drying Height) attribute which is not described in the spec.

contains NAM (Name) attribute which is not described in the spec.

BD100 (Pile/Piling/Post) [point feature]

contains HDP (Hydrographic Depth) attribute which is not described in the spec.

BD180 (Wreck) [point feature]

contains HDH (Hydrographic Drying Height) attribute which is not described in the spec.

contains NAM (Name) attribute which is not described in the spec.

contains TXT (Text Attribute) attribute which is not described in the spec.

36. 30.2.10.a (Port Facilities Coverage)

BB190 (Pier/Wharf/Quay) [area feature]

contains LOC (Location Category) attribute which is not described in the spec.

The following sections, taken from the DNC Prototype 3 review, present those items that were not addressed (fully) in Product 1. For reference, the same item numbers are used. Some of the comments that DMAP made in the previous review are clarified here.

#### 4.5 Unaddressed Recommendations/Comments on DNC Prototype 3

##### Cultural Landmarks

39. For the following features, the attribute OHC (Overhead Clearance Category) should be replaced by VRR (Vertical Reference Category): Aerial Cableway Lines/Ski Lift Lines (AQ010), Power Transmission Line (AT030), and Telephone Line/Telegraph Line (AT060). VRR references the overhead clearance to a datum, rather than the "traveled way." A ship wishing to pass under one of these features would need to know the height measured from a known datum.

42. Character of Light (COL) should be added to Building Superstructure Addition (AL018) and Air Obstruction Light (GA020) as these features may include lights that may aid navigation. This also should apply to any other features in any coverage of the DNC.

43. Accuracy Category (ACC) is not a necessary attribute for permanent structures such as Aerial Cableway Pylon/Ski Pylon (AQ020) and Power Transmission Pylon/Power Transmission Pole (AT040). These are fixed features and are highly unlikely to move.

##### Hydrography

49. The point to be made here is the confusion that may result from the use of depth curves vs. depth contours. DMA Chart No. 1 section I defines only depth contours. No mention is made of depth curves. While the definitions are distinguishable, the depth curve has no advantage over the depth contour. The DNC should use depth curves.

52. Soundings should be displayed as their numerical values, not as symbols so that this crucial information can be readily available to the user without performing a spatial query. This problem

could be addressed as a text feature or as a VPFVIEW consideration (if the value of an attribute is numeric, have VPFVIEW display the number rather than a symbol).

53. The attribute Sounding Category (SND) is confusing. What is meant by "condition of depth?" The FACS definition, "Type of Sounding," is more descriptive.

54. In many features throughout the DNC the attribute Date (DAT) is used with Value (VAL) for the same feature with VAL containing the year. Logically, the year should be included in the Date. One example is Sounding (BE020).

55. For the feature Bottom Characteristics (BF010), the attribute ordering causes confusion. The alphabetical ordering doesn't group the following six attributes in the natural grouping as shown below. This order shows the primary constituent of the top layer to the bottom layer. The first two items (a, b) should be made "more similar" by either a change in name or an additional note in the specification.

- a. Material Composition Category (MCC)
- b. Physical Surface Characteristics (PSC)
- c. Material Composition Secondary (MCS)
- d. Secondary Material Characteristics (CSM)
- e. Material Composition Underlying (MCU)
- f. Underlying Material Characteristics (UMC)

57. The attribute MCC is defined as "Composition material, excluding surface material." This is redundant since the composition of subsurface materials is described by the attribute MCS. MCC should be redefined as the Primary Surface Material Composition, since it is paired with the PSC as shown above. Currently, as they are defined, there is no attribute to describe the composition of the primary surface material. In the DNC prototype using FACS, Material Composition Primary was used for this purpose.

#### Inland Waterways

59. The Intercoastal Waterway, which is a major navigational channel, is not found in the DNC. It needs to be made a separate feature, or text added to label each portion, manmade and natural.

#### Land Cover

65. Here is an example of how feature classes, which should logically contain the same attributes, have different attribute lists: For EMBANKA.AFT (embankment as an area feature) attribute USE, "Levee/Dike" should be a possible value, since it is a possible value for LCRLINE.LFT (embankment as a line feature). Including such an attribute value in EMBANKA.AFT, even though it may not be currently used in the product, would prevent major updates later (see also 66).

#### Limits

66. The problem of area, line, and point features not having the same attributes is extreme in this layer. Whether a feature is displayed as an area, line, or point feature, the exact same attributes and possible attribute values should be available to all three feature classes. Attributes and attribute values should not be class dependent but feature dependent.

71. Radar Reference Line (FC130) is a navigational aid and should be moved to the Aids to Navigation Layer.

#### Aids to Navigation

76. The attributes for Aids to Navigation should be expanded so that at a minimum they contain all of the information found in the Light List and List of Lights. This would involve adding only a few more attributes to the DNC, but the time saved for the user would be enormous (Fig. 9). Additional attributes would describe the fixed structures upon which aids are mounted, any emergency lights, any seasonal remarks (some buoys are replaced or removed during winter), any private aid identification, and the year established, moved or rebuilt. This would significantly reduce the excessive entries of "Unknown" as currently done for attribute values (Fig. 10), thus making the DNC a more complete and informative database.

79. An attribute needs to be added to Buoy (BC020) to describe the way in which a buoy is patterned, i.e. checkered, vertical stripes, horizontal stripes, diagonal stripes. This information is readily available on the paper charts and in DMA Chart No. 1 (Fig. 11).

80. Add Maintenance Status (MAS) to all buoys, lights, markers, and beacons. This information is given on the paper chart for some of the navigational aids (i.e., the leading lights in the Craney Island spoil rehandling basin are Army maintained).

81. For Buoy Type Category (BTC), "Navigational" is what most buoys will be, and should be one of the possible attribute values. The proper values are readily available in the FACC Digest.

83. When giving light ranges, especially for multicolored lights, it needs to be specified which light has which range (i.e., 17W 15R).

84. If no color is given for a light, then it is white, not "Unknown." This data should be entered in the DNC database correctly.

85. A Sound Signal Characteristic attribute needs to be added to any feature (buoy, light) that has the Sound Signal Type (SST) attribute. It should include information describing the sound signal (i.e., period of the sound). The description of signal characteristics can be obtained from the Light List.

86. Latitude and Longitude need to be added attributes for navigational aids.

#### Obstructions

89. Ice Breakers at Cape Henlopen should be an added feature. These are shown on chart 12200. This brings up the issue of how the DNC will handle features that may appear on only one chart out of a thousand, and not be in the product specification. Recommend adding some sort of miscellaneous feature to all layers with the only attribute being text which names the feature.

#### Port Facilities

93. Pier numbers should be entered into the NAM attribute for Pier/Wharf/Quay (BB190), or Port Facilities text be added to name the piers. This information is readily available on the paper charts.

(1) No.	(2) Name and location	(3) Position	(4) Characteristic	(5) Height	(6) Range	(7) Structure	(8) Remarks
SEACOAST (North Carolina) - Fifth District							
N/W CAPE HATTERAS TO LITTLE RIVER INLET (Chart 11520)							
645 28625	Hatteras Inlet Light	35 11.8 75 44.0	Iso W 6 <sup>s</sup>	88	10	Skeleton tower on black house.	
650 28630	Hatteras Inlet Entrance Lighted Buoy HI		Mo (A) W		6	Red and white stripes with red spherical topmark.	Position frequently shifted with changing conditions.
655 28635	Hatteras Inlet Station Radiobeacon	35 12.5 75 42.4	HI (•••• ••)		30		FREQ: 306 kHz.
660	Ocracoke Light	35 06.5 75 59.2	F W	75	14	White tower.	
665 28895	Ocracoke Inlet Entrance Lighted Whistle Buoy OC		Mo (A) W		6	Red and white stripes with red spherical topmark.	Position frequently shifted with changing conditions.
670	Cape Lookout Light	34 37.3 76 31.5	FI W 15 <sup>s</sup>	156	25	Black and white diagonally checkered tower 169	Emergency light of reduced intensity when main light is extinguished.
675	Cape Lookout Slough East Lighted Buoy E	34 34.1 76 30.0	Mo (A) W		6	Red and white stripes with red spherical topmark.	
680	Cape Lookout Shoals Lighted Buoy 2	34 29.6 76 25.7	Q R		4	Red.	
685	Cape Lookout Lighted Bell Buoy 14	34 18.1 76 24.0	FI R 4 <sup>s</sup>		4	Red.	
690	Cape Lookout Shoals Lighted Bell Buoy 4		Q R		4	Red.	
695	Cape Lookout Shoal Lighted Buoy 6	34 27.2 76 33.7	FI R 6 <sup>s</sup>		4	Red.	
700	Cape Lookout Slough West Lighted Buoy W	34 33.8 76 32.8	Mo (A) W		6	Red and white stripes with red spherical topmark.	
705	Cape Lookout Shoals Lighted Buoy 8 Marks wreck of SENATEUR DUHAMEL.	34 32.9 76 36.2	Q R		4	Red.	
710 29125	Cape Lookout Breakwater Lighted Buoy 2	34 37.1 76 33.8	Q R		3	Red.	
715	Beaufort Inlet Dumping Ground Buoy A					Yellow can.	
720 29330	Beaufort Inlet Lighted Bell Buoy 2BI	34 38.4 76 40.6	FI (2) R 5 <sup>s</sup>		4	Red.	
725	Fort Macon Radiobeacon	34 41.8 76 41.0	CL (-••• ••••)		150		FREQ: 294 kHz.
730 29490	Bogue Inlet Entrance Lighted Whistle Buoy BI		Mo (A) W		6	Red and white stripes with red spherical topmark.	
735	Bogue Bank Wreck Lighted Buoy WR13 Marks wreck of SULIOD.	34 32.8 76 53.7	FI G 2.5 <sup>s</sup>		4	Green.	
Camp Lejeune Danger Zone							
740	- Lighted Buoy A	34 36.3 77 05.6	FI Y 4 <sup>s</sup>		6	Yellow.	

Fig. 9 — Excerpt from U.S. Coast Guard's Light List for Ocracoke Light [2]

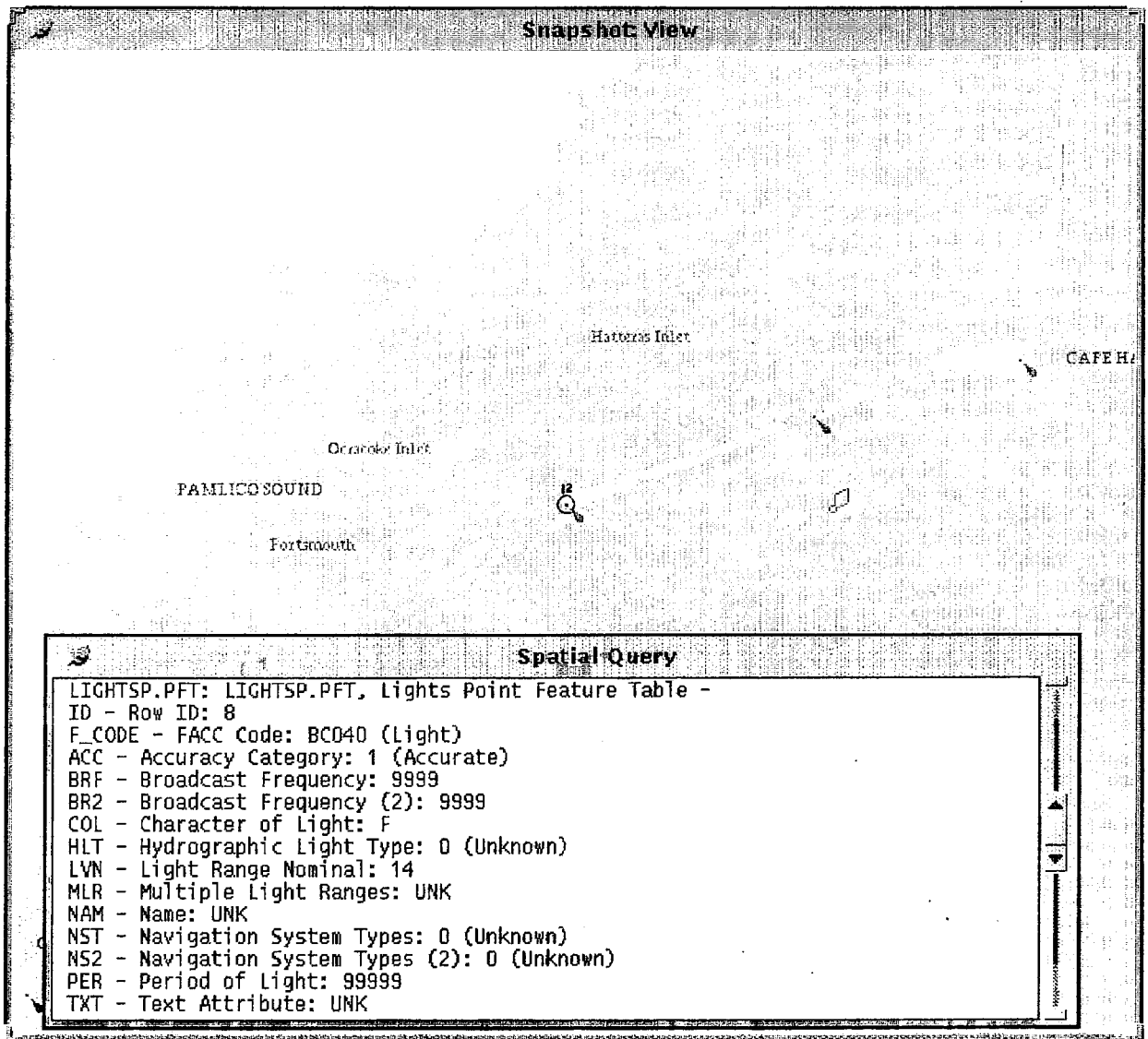


Fig. 10 — DNC data for Ocracoke Light

<b>Buoys and Beacons</b>			
IALA Maritime Buoyage System, which includes Beacons → Q 130			
1		Position of buoy	→
<b>Colors of Buoys and Beacon Topmarks</b>			
Abbreviations for Colors → P			
2		Green and black	
3		Single colors other than green and black	
4		Multiple colors in horizontal bands, the color sequence is from top to bottom	
5		Multiple colors in vertical or diagonal stripes, the darker color is given first	
6		Retroreflecting material	
<i>Note: Retroreflecting material may be fitted to some unlit marks. Charts do not usually show it. Under IALA Recommendations, black bands will appear blue under a spotlight.</i>			
<b>Lighted Marks</b>			
Marks with Fog Signals → R			
7		Lighted marks on standard charts	
8		Lighted marks on multicolored charts	
<b>Topmarks and Radar Reflectors</b>			
For Application of Topmarks within the IALA-System → Q 130      Topmarks on Special Purpose Buoys and Beacons → Q			
9		IALA System buoy topmarks (beacon topmarks shown upright)	
10		Beacon with topmark, color, radar reflector and designation	
11		Buoy with topmark, color, radar reflector and designation	
<i>Note: Radar reflectors on floating marks are usually not charted.</i>			

Fig. 11 — Buoy stripe data as shown in DMA Chart No. 1 [3]

## General Comments

95. The DNC 3 was delivered in the "Little-Endian" order. Recommend using "Big-Endian" order or both, since this slows down the use of DNC on most Navy Unix-based workstations.

### 4.6 DMAP DNC Prototype 2 Recommendations/Comments not yet Addressed

(Note: The same numbering scheme is used in this section as was used in DMAP's review of the DNC 2 prototype.)

#### General Remarks

3. In the table of feature attributes for each DNC feature, many of the attributes are not used when the data is available, or is left as "NULL." More attention must be paid to ensure that all available attributes are noted in the table, and that as many as possible of the others are found using all sources (Coastal Pilots, Light Lists, etc.).

9. Military bases and installations as a feature under Cultural Landmarks would be useful to Navy vessels. This is not a feature on the paper nautical chart.

#### Earth Cover

18. When Open Water, Ground Surface, or Island are queried, NAM should be added to their feature attribute tables. Different Ground Surface areas should be divided by administrative boundaries, and Open-Water areas should be divided by polygons representing the general geographic region of each Open-Water area.

#### Aids to Navigation

24. Sector lines for sector lights need to be included as a feature, as noted in DMA Chart No. 1 and shown on the paper chart.

## 5.0 CONCLUSIONS

The DNC has progressed through the prototyping process to represent a powerful tool for future Navy and Marine Corps use. However, there are still some areas noted for improvement that have not been incorporated. Most outstanding are the Environment layer and the amount of readily available information concerning navigational aids that is not entered into the database. The goal of the DNC should not be to merely digitize paper charts, raster products could meet this goal, but to provide the user with a comprehensive, detailed navigational tool which is a combination of current multiple paper products (i.e., Light List, List of Lights, Coastal Pilot, Radio Navigational Aids).

Another issue concerning the DNC is how it will be used. Several factors, such as symbology and GISs, become involved here. The DNC is designed to be used with a GIS, but DMAP has not been able to evaluate the DNC on this type of platform because there is no available software to allow the DNC, or any VPF product, to be read with a GIS.

Once the issues itemized in this review have been addressed, the DNC will be a great asset for navigational and other Navy uses. DMAP strongly recommends that these items be addressed prior to operational distribution and use.

## 6.0 ACKNOWLEDGMENTS

This effort was funded by the Oceanographer of the Navy under Program Element 0603207N within the DMAP, and managed in NRL's Tactical Oceanography Warfare Systems Program Office.

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