ARHC4-4.6

Paper for Consideration by ARHC

Update on

Submitted by:	TSMAD Vice Chair
Executive Summary:	This paper is to update the ARHC on the progress of portraying ENC data on an ECDIS at high latitudes.
Related Documents:	ARHC2-08A,B TSMAD22/DIPWG3 INF2
Related Projects:	Any related projects that may impact upon considerations

Introduction / Background

In 2011, Denmark on behalf of the ARHC submitted an information paper to TSMAD regarding the use of ENCs in Polar Regions. This paper recommended that the Polar Stereographic projection was the appropriate projection for the display of high latitude ENCs within an ECDIS.

Analysis/Discussion

The ARHC paper resulted in a general TSMAD action to consider how to resolve the issue of polar projection of an ENC within an ECDIS for high latitude navigation. After some investigation, it was determined that this issue was not as simple as specifying a certain projection above 85° and supplying appropriate ENC test datasets, but that TSMAD would also have to consult with IEC TC80 to create specific tests within IEC 61174 – *Electronic chart display and information system (EDCIS) Operational and performance requirements, methods of testing and required test results* for the ECDIS to portray the ENC data correctly along with ensuring that the route monitoring and position fixing also work correctly, in addition to supplying test data for S-64 – *IHO Test Data Sets for ECDIS*.

As a result the following actions were completed:

1. IEC 61174 now contains a clause called Operational Area. This clause specifies that all ECDIS must handle ENCs between 85° N and 85°S and if the ECDIS chooses to support ENCs above and below these limits they must declare this in the User Manual and support the new conformance tests within IEC 61174. (Annex A).
2. TSMAD has included several datasets and tests to ensure that if an ECDIS wants to certify that it can operate above 85°N or below 85°S that it will portray ENC data correctly. (Annex B)

It should be noted that neither IEC 61174 nor S-64 specifies which projection should be used for the display of ENCs in high latitudes. IEC 61174 does state the following:

> Chart projection types in addition to Mercator may be provided. If the stated maximum latitude of the ECDIS is greater than 85 degrees, then at least one chart projection type suitable for navigation in higher latitudes should be provided in addition to Mercator projection. The user manual shall state the projection types provided and describe the user interface involved in transitioning from one projection type to another.

Conclusions

It was determined that because there was very little navigation in high latitudes and that the current draft of the Polar Code does not make an explicit reference to electronic charts, but rather includes the following indirect requirement "S*ystems for providing reference headings and position fixing shall be suitable for the intended areas"* that gave IEC TC80 some leeway in establishing optional tests for ECDIS to be certified in high latitudes. If the ECDIS manufacturer would like to be certified for high latitude navigation then they meet the type approval requirements that are laid out in IEC 61174 and S-64.

These two publications are on track for approval and publication in the fall of 2014 for an implementation data of September 2015.

Action Required of ARHC

The ARHC is invited to:

a. note the progress of TSMAD regarding the use of ENCs in high latitude navigation for an ECDIS

b. note the progress of IEC TC80

Annex A – Extracts from the draft IEC 61174 (set for publication in late 2014).

5.10 Operational area

(See 6.8.18.)

The North Pole and the South Pole are special cases around which there exists very little general navigation. Therefore every ECDIS is not requested to handle ENC chart including the pole itself. The limit is latitude 85°. Every ECDIS is required to operate until 85°N and 85°S. Optionally, an ECDIS may support operation above latitude 85°. The manufacturer shall declare the operational area of the ECDIS in the user manual.

6.8.19 Operational area

(See 5.10.)

ENC charts below latitude 85° is verified by conformance to 6.5.1

Confirm by inspection of documented evidence that the manufacturer has declared in the operator manual the operational area of the ECDIS.

If the declared operational area extends above latitude 85° then:

a) ENC charts above latitude 85° is verified by conformance to 6.5.1 ;

b) confirm by analytical evaluation that a chart projection type suitable for navigation in higher latitudes is provided; Confirm by inspection of documented evidence that the user manual states the projection types provided and describes the user interface involved in transitioning from one projection type to another;

c) use charts available in the IHO S-64 and confirm by observation that functions such as route planning, route Monitoring, etc. are operative above latitude 85°;

1) plan complex tracks using scenario 4 as noted in Annex I and save the tracks. Confirm by observation that track distances comply with those noted in Annex I and that no distortions are visible;

2) If there is a maximum latitude limit for the EUT, confirm by observation that an alert (caution) is provided when the route falls within a region beyond the maximum latitude;

3) reload the complex route of scenario 4 and start monitoring the route with the first waypoint. Confirm by observation that all waypoint changes, bearings and distances are calculated and displayed correctly during route monitoring;

4) Confirm by observation that the alert requirements that apply to hazardous areas are also implemented for areas with latitude exceeding the maximum at which the ECDIS is fully functional.

5) The test 1-4 above shall be repeated for each projection type provided by the ECDIS.

d) use charts available in the IHO S-64 and confirm by observation that accuracy of LOP, VRM, EBL, etc. measurements is within tolerances.

1) Confirm by observation that the accuracy of range and bearing measurements relative to charted data of S-64 scenario(s) using the tools provided by the ECDIS (VRM, EBL, ERBL, etc.) is within 1 % or 30 m whichever is greater for distances and within 1° for bearings. The northern-most edge of the displayed chart shall be set to 90° latitude or at the highest latitude specified by the manufacturer. Measurements shall include points at extreme distances NW, NE, SE and SW of own ship at a small scale like 1:200,000 or the smallest scale supported by the ECDIS and the S-64 test data set at that latitude.

2) Perform tests described in 6.9.7 in a region above 85° latitude.

e) if the presentation of radar tracked target data, AIS information and radar overlay image is provided, confirm by observation that when compared with the displayed chart, the overlaid data match in scale, orientation, projection and accuracy, within the ranges defined in IEC 62388.

Annex S
(informative)

Guidelines on use of electronic chart systems in polar waters

S.1 Background information

IMO adopted guidelines for ships operating in polar waters in Resolution A.1024(26):2010. This resolution states: The Guidelines for ships operating in polar waters (hereinafter called “the Guidelines”) are intended to address those additional provisions deemed necessary for consideration beyond existing requirements of the SOLAS and MARPOL Conventions, in order to take into account the climatic conditions of polar waters and to meet

appropriate standards of maritime safety and pollution prevention. In this annex, it is referred to as "the Polar Guidelines". IMO is now developing an International Code of Safety for Ships Operating in Polar Waters referred to herein as "the Polar Code".

S.2 Navigation equipment requirements of the Polar Guidelines and Polar Code

S.2.1 Heading sensor

The Polar Guidelines advise and the draft Polar Code requires that when going "above [75] degrees" compliant vessels should carry a "GPS-based compass or equivalent", i.e. carry an additional GNSS-based Transmitting Heading Device (THD) per MSC.116(73) and ISO 22090-3. It is risky to assume solely on the basis of the sensor technology employed that a given gyrocompass meets requirements for navigation accuracy above 70 degrees. As noted in the draft Polar Code, the IMO minimum performance requirements for standard SOLAS gyrocompasses specify compliance only for latitudes up to 60 degrees [A.424(XI):1979]. For high speed craft, the latitude is increased to 70 degrees [A.821(19):1995]. The sensor of a THD is required to operate to 70 degrees latitude, "except when a geographical area is specified in applicable IMO performance standards", i.e. except for standard gyrocompass sensors. [MSC.116(73):2000]

S.2.2 Radar

Both the Polar Guidelines and draft Polar Code advise carriage of radar with enhanced capability for ice-detection. The draft Polar Code points out that no standards exist for radars with enhanced ice-detection capability.. Standards for ice discrimination are similarly lacking. Capt. Toomey, Canadian Coast Guard (Ret), has pointed out need for discrimination of different types of ice, as well as the problem of intermittent detection of isolated bergy bits and growlers, observing that radar provides "…too many radar returns from ice that is not at all hazardous". [Ref "Ice Navigation in the Electronic Age" e-Nav International, 21Jun2013].

S.2.3 Ice imagery

The draft Polar Code also requires carriage of equipment capable of displaying ice imagery. Although SOLAS IV requires reception of weather information including ice warnings, existing performance standards only require display of text, information, not display of graphics or imagery of ice areas. The standardized display of ice area information on ECDIS and Chart Radar is a capability is envisioned in the future, based on the IHO S-100 framework. The presentation requirements of IEC 62288 for display of additional information on electronic charts apply (62288/6.3.8).

S.3 ECDIS performance considerations for polar latitudes.

S.3.1 Position fixing

The current draft Polar Code makes no explicit reference to electronic charts but includes the indirect requirement that "Systems for providing reference headings and position fixing shall be suitable for the intended areas." Charts and suitable display of charted information are fundamental to position fixing. (Refer to SOLAS V/19.4, draft Polar Code DE_57-WP.6-Add.1 and comments from NAV to DE in NAV58-WP.5)

S.3.2 Projection and coordinate system

Using north-referenced bearing coordinates, ship motion extrapolated into the future (i.e. a straight track along a great circle) does not follow a constant bearing. In this coordinate system, lines of constant bearing follow the path of rhumb-lines (loxodrome curves) that gradually spiral into the pole. These lines of constant bearing are transformed by Mercator projection into straight lines, however, the same transformation changes the path of straight tracks the line of sight from visual bearings, etc. (i.e. great circle) into curves with significantly increasing non-linearity approaching the poles. At low latitudes, over the distances of concern to a navigator, the non-linear divergence is of little consequence and is barely noticed. At high latitudes, however, the effect can be significant and reduces the utility of the Mercator projection for navigation. Some systems specialized for use in polar waters have implemented alternative projection methods and coordinate systems which have long been established to correct this situation while providing the useful characteristics of Mercator. However the use of these alternatives has not been standardized.

Review of paper charts and a sample of ECDIS displays was conducted by the International Hydrographic Bureau. It observed that, at present, few ENCs are available for Polar waters in Navigation Purpose bands 3 to 6

(coastal, approach, harbour, and berthing). Although the criteria was not made clear, this IHB study concluded that a chart display and associated computations based on the Mercator projection are adequate up to 85° latitude. All navigable areas in the Antarctic have a latitude less than 85°. Much of the expected traffic in polar regions operate at latitudes less than 85°N." [TSMAD26/DIPWG5-12.8A] [In current ECDIS practice, there appears to be some consensus that Mercator should not be used beyond approximately [85°] for display at the scales commonly used for navigation, i.e. scales 1:1,500,000 or larger.]

Practical criteria for minimally acceptable navigation accuracy and uniformity across a displayed chart area might be based on maintaining accuracy requirements as specified for radar in MSC.192/5.2, i.e. Range - within 30 m or 1% of the range scale in use, whichever is greater; Bearing - within 1°. These criteria can be used to define limits on the largest scale Mercator projection that may be used at various polar latitudes. Refer to the tables provided in informative Annex R.

For ECDIS, the User Manual provided by the manufacturer should state the maximum latitude north or south at which in the ECDIS is capable of meeting the performance required: (a) calculations and measurements "consistent with the SENC accuracy" [61174/6.6] and (b) track data, AIS information and radar overlay image, when compared with the displayed chart, that "match in scale, orientation, projection and accuracy, within the ranges defined in IEC 62388." [61174/ 6.8.13] The stated maximum latitude should be at least 85 degrees. Any limits imposed on the selection of display scales available at higher latitudes shall also be described.
Chart projection types in addition to Mercator may be provided. If the stated maximum latitude of the ECDIS is greater than 85 degrees, then at least one chart projection type suitable for navigation in higher latitudes should be provided in addition to Mercator projection. The user manual shall state the projection types provided and describe the user interface involved in transitioning from one projection type to another.

S.3.3 Consistency

Overlay of information on ECDIS chart display of information from other sources (i.e. satellite imagery) and the generation of measurements taken using ECDIS navigation tools must be consistent with respect to the type of chart projection and the coordinate system used.

S.3.4 ECDIS additional tests to include navigation in polar waters

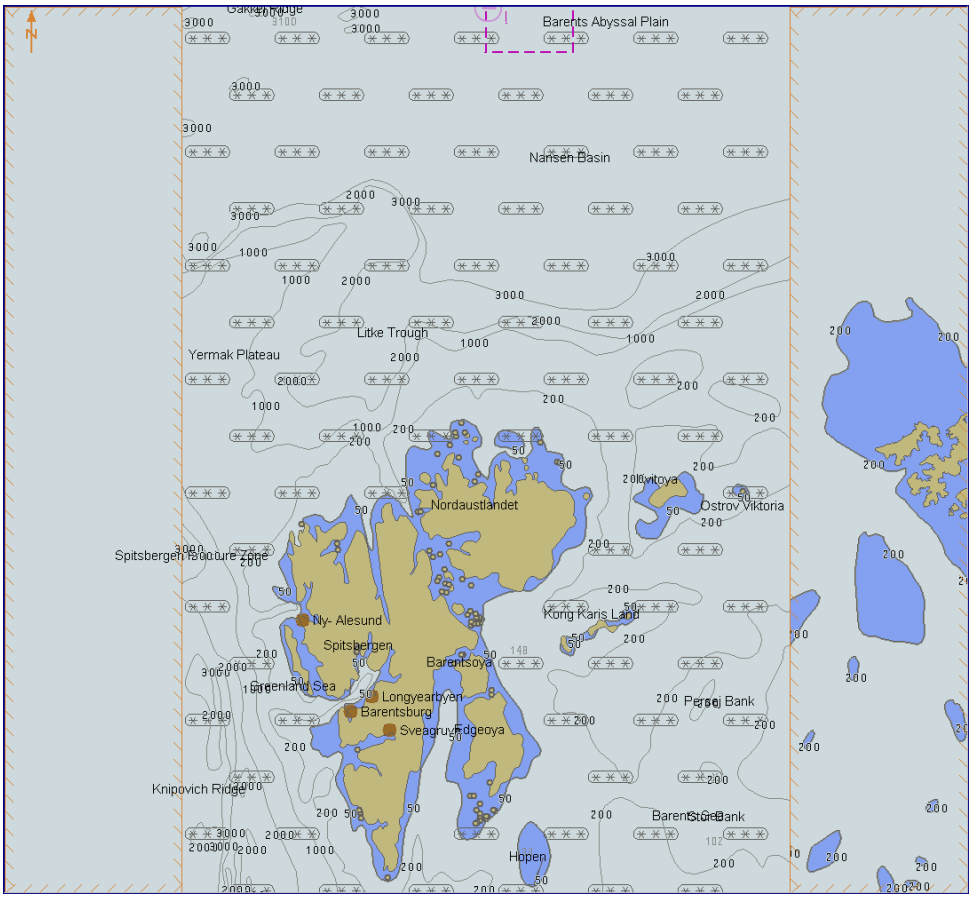
An added test data set in S-64 would be useful to ensure that the orientation and accuracy requirements can be confirmed during type testing for latitudes between 60N and 85N [or further north]. The development of such an S-64 ENC test datasets falls under the responsibility of IHO's TSMAD. Such tests should include:

a) Verify the user manual states the maximum latitude at which the ECDIS meets accuracy requirements without restriction on display scales, that this limit is at least 85 degrees, and that it describes limits imposed on selection of display scales at higher latitudes or other limitations of functionality at higher latitudes . (New)
b) Verify, when the maximum latitude is greater than 85 degrees, that the user manual states the projection types available and describes the user interface involved in transitioning from one projection type to another. (New)
c) Verify that during voyage planning, an [alert] is provided to when a route falls within a region beyond the maximum latitude at which the ECDIS meets accuracy requirements without restriction on display scales. (New)
d) Verify that the [alert] requirements that apply to hazardous areas are also implemented for areas with latitude exceeding the maximum at which the ECDIS is fully functional.(New)
The tests below should be repeated for each projection type provided by the ECDIS:
e) Verify by measurement the accuracy of range and bearing measurements relative to charted data of S-64 scenario(s) using the tools provided by the ECDIS (VRM, EBL, ERBL, etc.). The northern-most edge of the displayed chart shall be set to [80] degrees or at the highest latitude specified by the manufacturer. Measurements shall include points at extreme distances NW, NE, SE and SW of own ship at [a small scale like 200,000:1 or the smallest scale supported by the ECDIS and the S-64 test data set at that latitude]. (See 61174/ 6.6)
f) Verify position accuracy resulting from entering data provided for the S-64 scenario(s) for visual/optical line of position. (See 61174/6.9.7.)
g) Verify the accuracy in range and bearing of displayed radar echo overlays, track data, AIS symbology and data with chart display and radar/AIS simulator data. (See 61174/6.8.13)
h) Verify, if provided, the position accuracy of any additional displayed information overlays such as ice information data and ice imagery with displayed chart data. Verify compliance of the presentation of additional displayed information in accordance with IEC 62288/6.3.8.

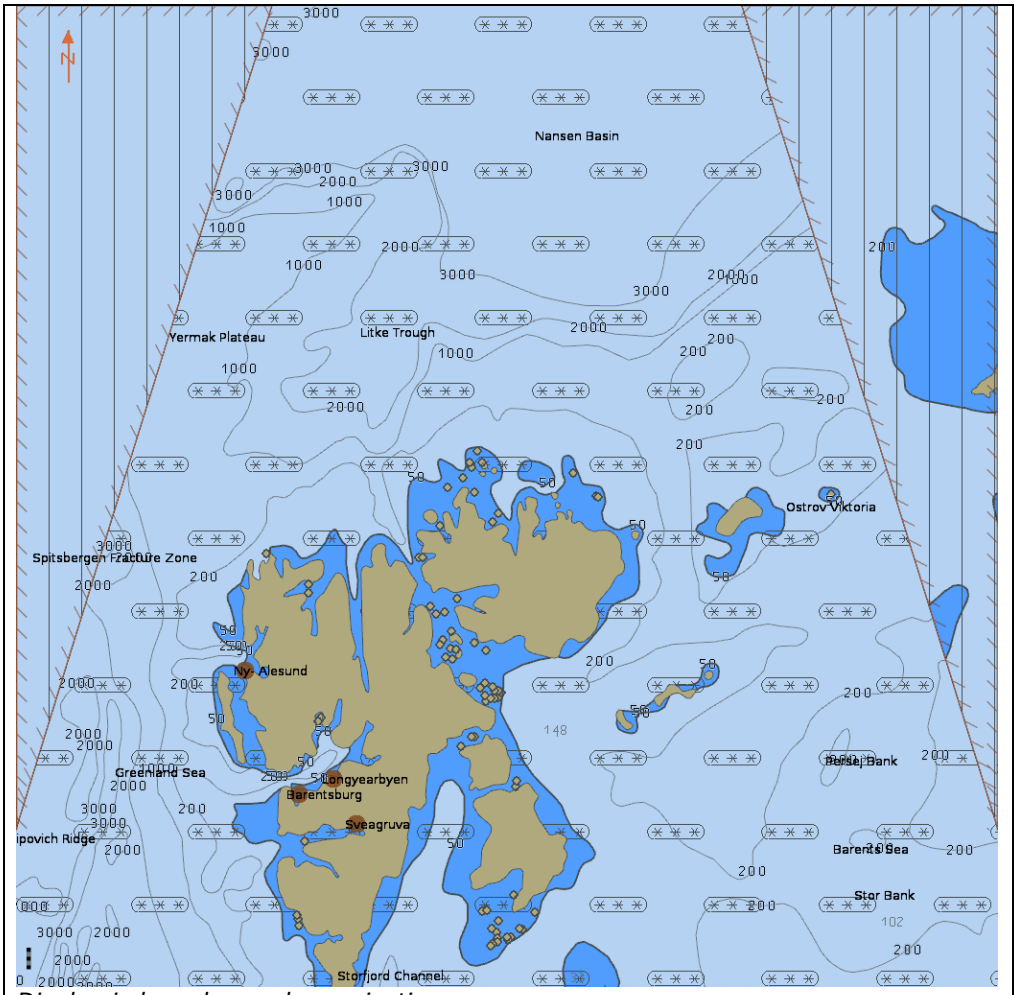
3.9 Display of ENC covering Polar Regions

3.9.1 Display of ENC Data up to 85 degrees

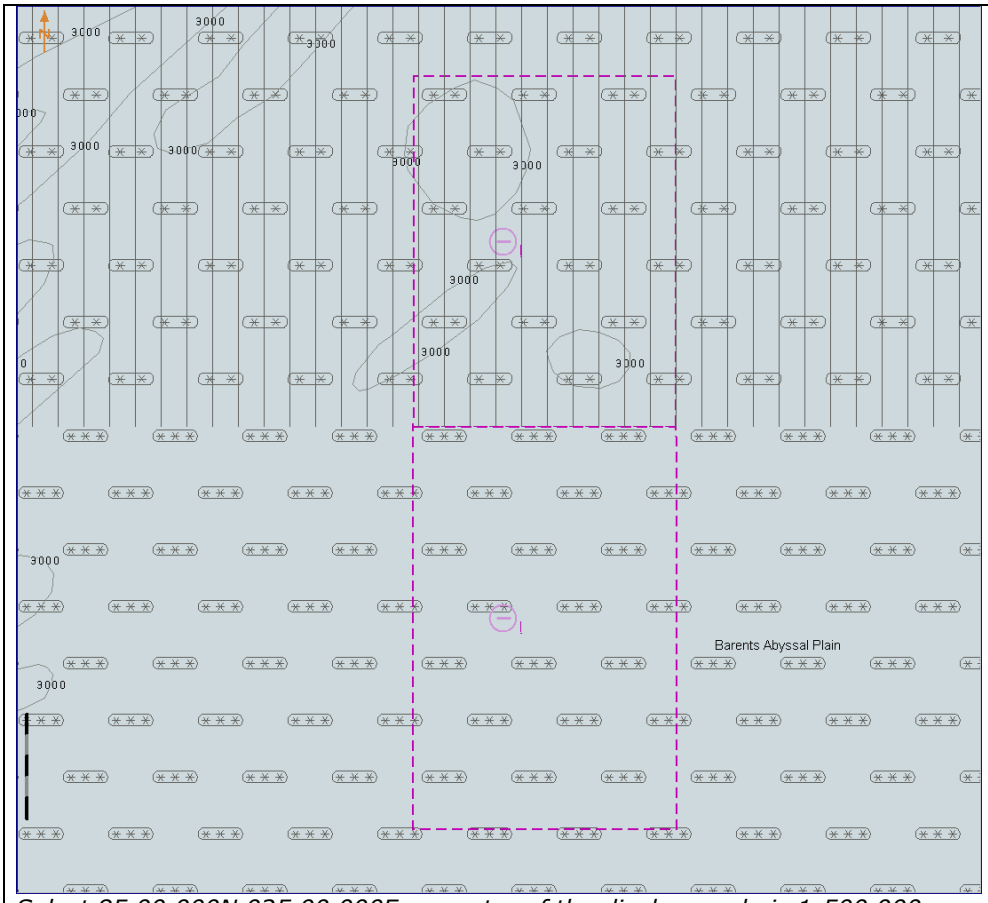
Test reference	3.9.1	IHO reference	S-52 10.1.10.2
Test description			
Display of charts up to 85 degrees.			
Set up			
Load the all cells from 3.9 Polar ENC Data *Select Display mode = Other* *Select Safety Contour = 30 metres* *Select Plain Boundaries* *Select Paper chart symbols*			
Action			
Select chart AA1NPOL3.000 at compilation scale (1:3 000 000) *Check ENC symbols shown in the ECDIS against the graphical plot.*			
Result			
The ENC in the ECDIS should be shown like in the picture below.			



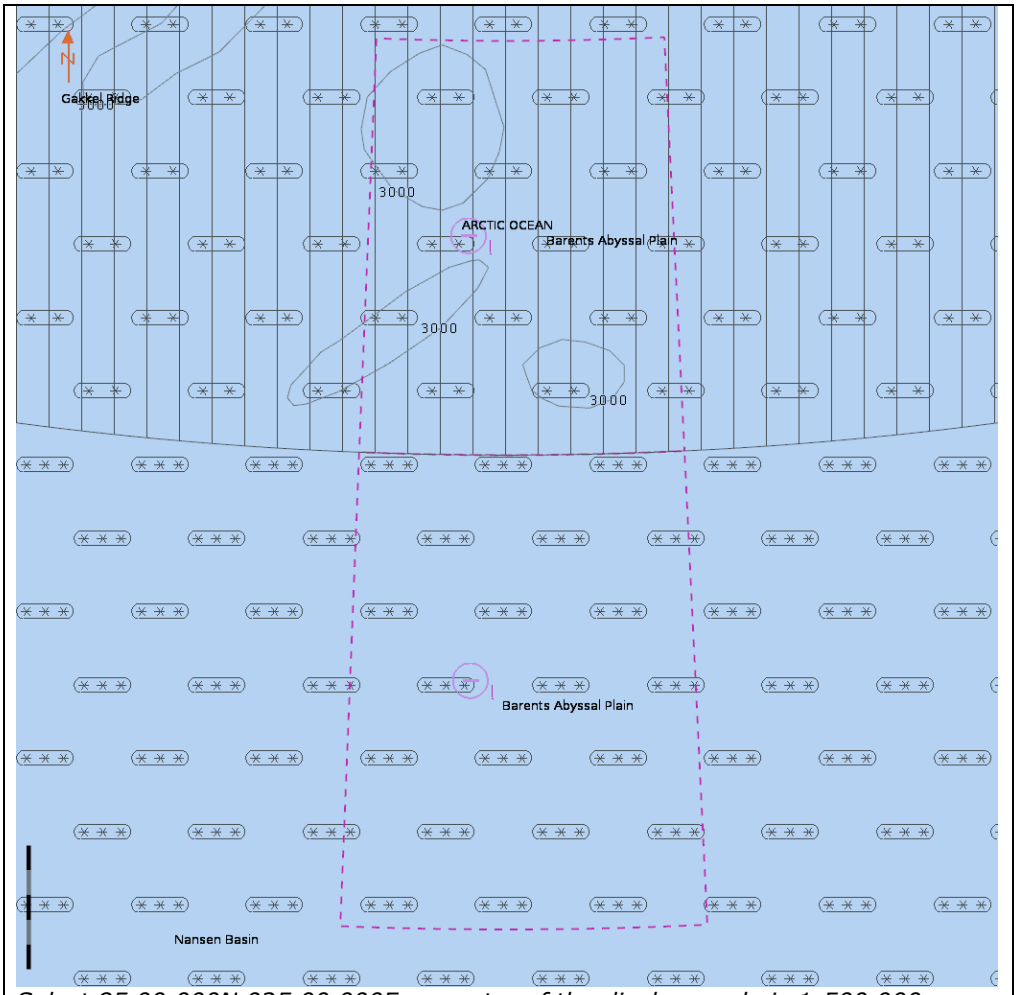
Display is based on Mercator projection



Display is based on polar projection



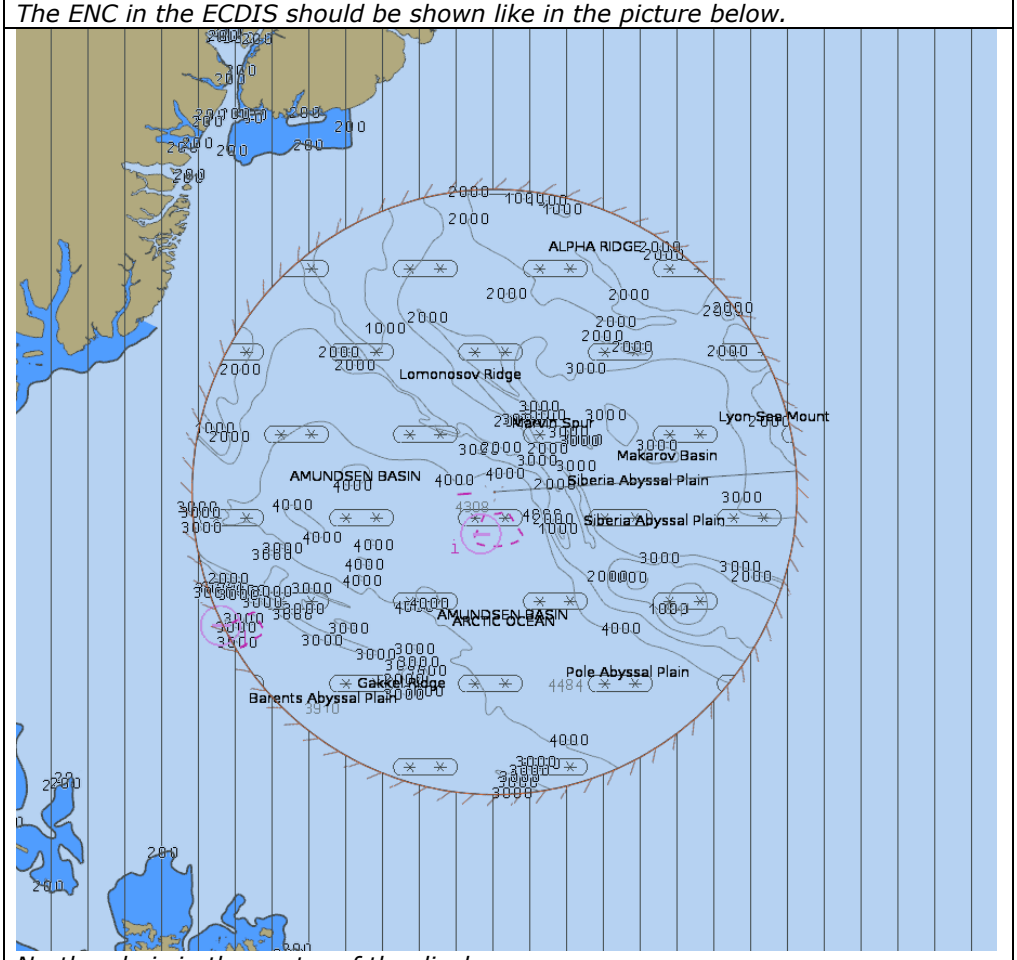
Select 85 00.000N 025 00.000E as centre of the display, scale is 1:500 000
Display is based on polar projection



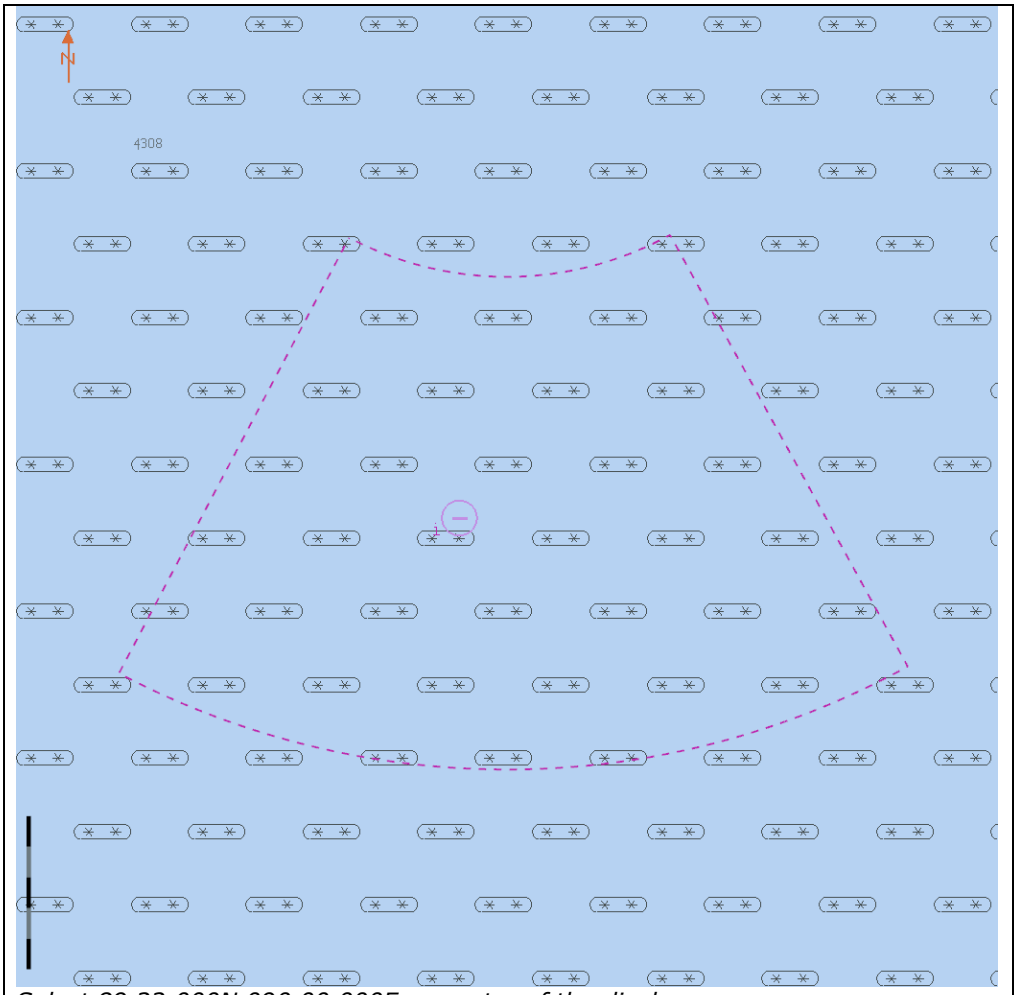
Select 85 00.000N 025 00.000E as centre of the display, scale is 1:500 000
Display is based on polar projection

3.9.2 Display of Data at Extreme High Latitudes

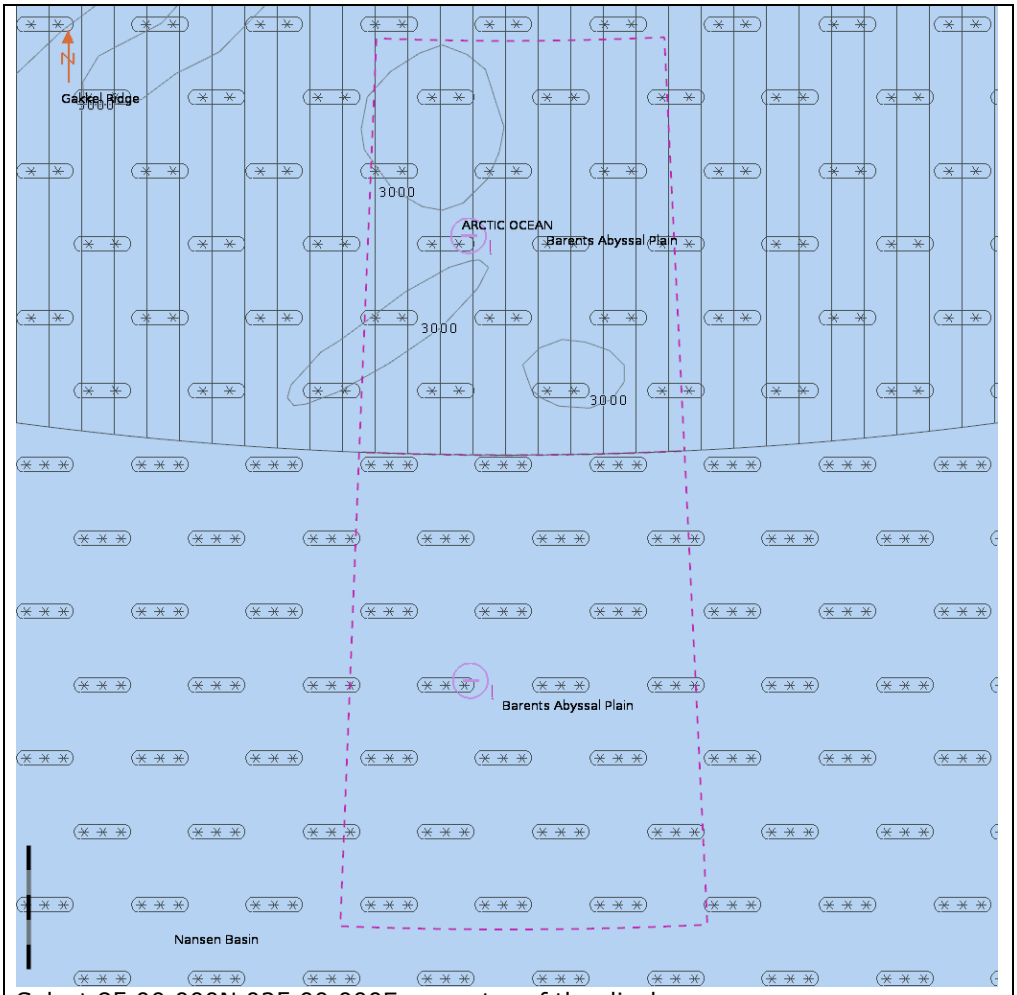
Test reference	3.9.2	IHO reference	S-52 10.1.10.2
Test description			
ONLY TO BE TESTED FOR EQUIPMENT CLAIMING THE CAPABILITY TO DISPLAY ENC DATA AT LATITUDES GREATER THAN 85 DEGREES *Display of charts above 85 degrees.*			
Set up			
Load the all cells from 3.9 Polar ENC Data Polar areas *Select Display mode = Other* *Select Safety Contour = 30 metres* *Select Plain Boundaries* *Select Paper chart symbols*			
Action			
Check ENC symbols shown in the ECDIS against the graphical plot.			
Result			
The ENC in the ECDIS should be shown like in the picture below.			



North pole is in the centre of the display



Select 89 22.000N 090 00.000E as centre of the display



Select 85 00.000N 025 00.000E as centre of the display