ORGANIZACION HIDROGRAFICA INTERNACIONAL

Dossier del BHI No. S3/8151/DQWG

INFORME RESUMIDO SOBRE UN CUESTIONARIO DE ENCUESTA DEL GRUPO DE TRABAJO SOBRE LA CALIDAD DE DATOS A LOS NAVEGANTES SOBRE LA COMPRENSIÓN Y EL USO DE LOS INDICADORES DE CALIDAD PARA DATOS CARTOGRÁFICOS

Referencias: a) Circular del BHI No. 23/2011 del 11 de Marzo;
b) Acción 13 del HSSC3 (Mónaco, 8-10 de Noviembre del 2011).

Estimado(a) Director(a),

1.   En el 2011, el Grupo de Trabajo sobre la Calidad de Datos (DQWG) preparó un cuestionario para determinar si los navegantes comprendían bien los indicadores de calidad de los datos existentes utilizados en las cartas de papel y en las ENCs. Un cuestionario fue distribuido junto con la Circular indicada en la referencia a), solicitando a los Estados Miembros que atrajesen la atención de los navegantes sobre su contenido. Esta Circular informa sobre los resultados del cuestionario, según lo requerido en la acción mencionada en la referencia b).

2.   El resultado de la distribución de dicho cuestionario fueron más de 550 respuestas, de las cuales el 67% procedió de navegantes con más de 10 años de experiencia. Esto permitió al DQWG identificar las deficiencias en el modo en el que se representa la calidad de datos en las cartas hoy en día y será útil para la preparación de propuestas de mejoras sobre la representación de la calidad de datos en las ENCs basadas en la S-100 y en otros productos en el futuro.

3.   El DQWG ha sacado las siguientes conclusiones clave:

- Una gran proporción de usuarios de ENCs no utilizan la información CATZOC (77%);

- Una gran proporción (75%) de navegantes que utilizan cartas con un diagrama ZOC indicaron que utilizaban la información contenida en el cuestionario. Esto deja pensar que lo que no les gusta a los navegantes es la aplicación digital de CATZOC, y que no hay ninguna clara preferencia por indicadores de calidad individuales con respecto a los compuestos;

- No se comprenden ni utilizan los atributos del indicador de calidad de datos adicionales disponibles en los datos S-57;

- Aunque los resultados muestran que los navegantes son conscientes de la importancia de la comprensión de la naturaleza del fondo del mar, no es evidente que entiendan cómo cambiará una evaluación o una designación de la calidad de esta información con el tiempo.

- Una mayoría de navegantes afirman que no han recibido formación suficiente sobre temas relacionados con la calidad de datos, y que desearían beneficiar de formación adicional;

- Parece haber una neta preferencia por la delimitación clara de zonas uniformes de calidad de datos. Un elevado porcentaje de navegantes indicaron que utilizaban la información en los diagramas fuente y ZOC antes que la visualización CATZOC. Este se vió reforzado adicionalmente por los resultados de las preguntas sobre los futuros desarrollos, que han mostrado que la opción preferida es una 'superposición de colores a la demanda'.

4.   El DQWG ha tomado en cuenta los resultados de la encuesta y ha elaborado los principios siguientes para el desarrollo de futuros métodos de representación de la calidad de datos en las ENCs:

- Como mínimo, los elementos que componen la CATZOC de la S-57 (incertidumbre en la posición, incertidumbre de sondaje, características detectadas y cobertura del fondo marino) deben ser codificados como atributos distintos de las ENCs de la S-101.

- Toda la información codificada sobre la calidad de datos debe poder descubrirse;

- La degradación temporal de la calidad de datos deberá reflejarse en los datos codificados;

- La representación de la calidad de datos deberá poder reflejar información como las mareas dinámicas, la compensación bajo la quilla y los parámetros específicos del buque;

- Cuando sea posible, los nombres de los atributos de las ENCs que estén disponibles para el navegante deberán ser más intuitivos, evitando por ejemplo los acrónimos de 6 letras de la S-57;

- La representación de la calidad de datos deberá tener en cuenta la preferencia del navegante por una superposición de colores a la demanda;

- Todo método de representación de la calidad de datos deberá ir acompañado de una estrategia de enseñanza adecuada.

5.   Se adjunta en el Anexo A un resumen (*en Inglés*) del análisis y los resultados del cuestionario. Este resumen se basa en un documento presentado por el Sr. Samuel HARPER del SH del RU, miembro del DQWG, a la Conferencia Hidrográfica Canadiense del 2012, celebrada en las Cataratas del Niágara, Canadá, del 15 al 17 de Mayo del 2012.

6.   El BHI da las gracias a los Estados Miembros por su apoyo en la difusión del cuestionario del DQWG.

En nombre del Comité Directivo
Atentamente,

Robert WARD
Director

Anexo A: *Summary of the Analysis and Results of a Survey of Mariners Concerning the Portrayal of Data Quality in Charts (*en Inglés únicamente*).*

**Summary of the Analysis and Results of a Survey of Mariners
concerning the Portrayal of Data Quality in Charts**

EXECUTIVE SUMMARY

With any physical measurement comes a level of uncertainty as to its accuracy. In the context of hydrographic surveying for navigational purposes, this uncertainty propagates through from data acquisition to data processing and on to chart compilation, increasing and becoming harder to quantify as it goes. It is therefore imperative that we have meaningful, useful and intuitive methods of representing this uncertainty so that the end user, the mariner, understands the limitations of the data by which he navigates.

The representation of geospatial data quality in a GIS environment is well researched with many different methods employed. The same is not true for the representation of data quality in Electronic Navigational Charts (ENCs). There is a concern amongst the international hydrographic community that the current methods of representing data quality in navigational products are not meeting the needs of the mariner. Instead they rely heavily on the user's ability to understand the relevance of data quality indicators such as 'survey date' and 'acquisition method' or composite quality classifications like CATZOC.

This study discusses the results of a questionnaire on the mariner's current perception of data quality in both paper and digital charts. The questionnaire was distributed internationally amongst a broad range of both professional and leisure mariners. With over 550 responses, 67% of which are from mariners with over 10 years of experience, it has been possible to identify aspects of current data quality representation that are not fulfilling the mariner's needs with respect to safe navigation. In conclusion, a specification is suggested for the development of a new approach to representing data quality in ENCs.

1.   INTRODUCTION

Current methods of representing the quality of the source data used to compile a navigational chart fail to provide mariners with the information they need to objectively decide where they can safely navigate. Instead they rely heavily on the mariners' ability to understand the relevance of data quality indicators such as 'survey date' and 'acquisition method' or composite quality classifications like CATZOC (Category of Zone of Confidence).

With the use of electronic navigational charts on the increase, and ECDIS mandation on the horizon, never has it been more necessary for us to ensure that the limitations of charted data are fully understood.

As bathymetric data acquisition systems become ever more sophisticated, understanding the implications of combined uncertainty and error become more complex. It is unreasonable to expect the professional mariner to be able to assimilate all of this extra information and draw valid inferences from it. Instead we need to better understand their requirements and expectations, and utilise developments in technology to develop better means of representing data quality.

In 2011, the International Hydrographic Organisation's (IHO) Data Quality Working Group (DQWG) undertook a study into the Mariners' perception of data quality. The principle aim of this project was to develop and recommend a specification for the development of any new means of representing data quality in future ENCs. This specification would take into account why mariners need data quality information, how mariners currently use data quality information, what mariners need from data quality information and the limitations of providing data quality information.

The results of this study and the specification derived from them are detailed in this paper.

2.   BACKGROUND

2.1   Data Quality and Uncertainty as a Concept

When we talk about representing data quality we are in essence trying to depict in a contextualised manner the total combined uncertainty of the bathymetric data from acquisition through to compilation. This is highlighted by Pang et al. [1997] who identified three instances in the "visualisation pipeline" where uncertainty is encountered: collection uncertainty due to measurements and models in the acquisition process, derived uncertainty arising from data processing and manipulation (cleaning, gridding etc.), and visualisation uncertainty introduced during the process of chart compilation. In addition to these three instances a fourth can be identified; once charted, data quality will suffer temporal degradation due to changes in seabed topography.

2.2   Challenges in representing data quality and uncertainty

Buttenfield [1993] suggests that there are three problems with the effective representation of uncertainty; Firstly uncertainty itself is an "ill-defined concept" with little distinction being made between similar concepts. It is also the case that the terminology used to describe these concepts is poorly understood and frequently misused. Secondly, it is difficult to measure multiple aspects of uncertainty, such as temporal degradation and random error, in a geospatial environment. Thirdly, it is difficult to represent uncertainty simultaneously with the data it describes.

MacEachren [2005] goes further than Buttenfield [1993] and identifies 7 more challenges:

1. Understanding the components of uncertainty and their relationships to domains, users, and information needs.

2. Understanding how knowledge of information uncertainty influences information analysis, decision making, and decision outcomes.

3. Understanding how (or whether) uncertainty visualisation aids exploratory analysis.

4. Developing methods for capturing and encoding analysts' or decision makers' uncertainty

5. Developing representation methods for depicting multiple kinds of uncertainty

6. Developing methods and tools for interacting with uncertainty depictions

7. Assessing the usability and utility of uncertainty capture, representation, and interaction methods and tools.

2.3   Existing methods of representing data quality in navigational charts

There are many types of navigational products available, each with different methods of representing data quality to the mariner. Generally these products fall into two categories; official government endorsed products and non-official products. The representation methods described below are found in official government endorsed products and as such their use is controlled by international standards.

2.3.1   Source or reliability diagram

Figure 2.3.1 shows an example of a source diagram, as found on a British Admiralty Paper Chart. It shows the individual areas of survey coverage, along with the year of completion, Survey authority, scale and sometimes acquisition method. In order for this to be useful the mariner must be able to infer from these data quality indicators what affect they will have on the quality of the survey.
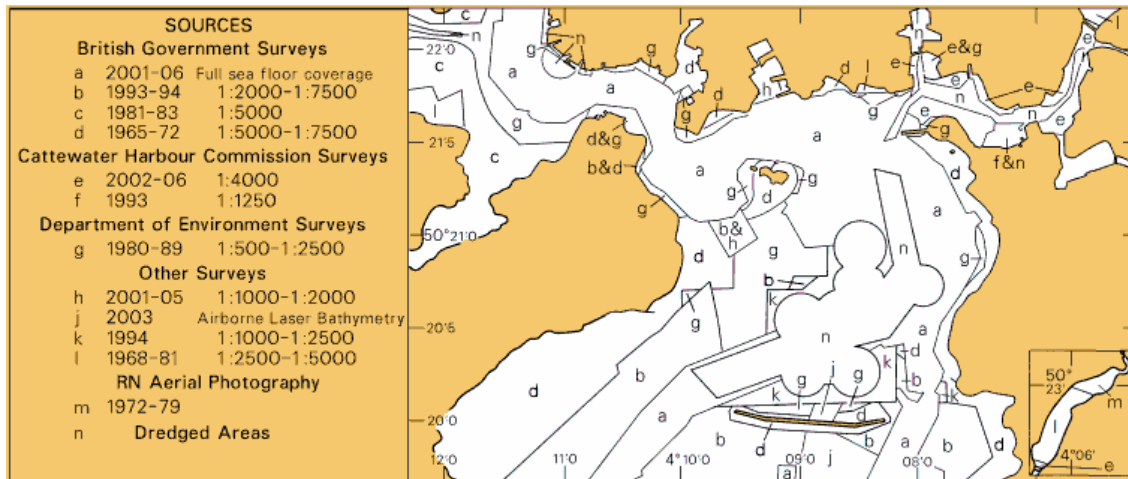
Figure 2.3.1 Source Diagram

2.3.2 Category of Zone of Confidence

Category of Zone of Confidence (CATZOC) is the primary indicator of data quality in ENCs. It is an S-57 attribute that is populated with a composite indication of the quality of the bathymetric data in a specific area. It differs from the source diagram in that it gives an overall indication of the quality of the charted data rather than providing individual data quality indicators. The various CATZOC categories are summarised in Table 2.3.1. CATZOC also has its own symbology and it can be toggled on and off depending on the preferences of the user.

ZOC	Position Accuracy	Depth Accuracy	Seafloor Coverage
A1	± 5m + 5% depth	0.5m + 1% depth	Full area search undertaken. Significant seafloor features detected and measured.
A2	± 20m	± 1m + 2% depth	Full area search undertaken. Significant seafloor features detected and measured.
B	± 50m	± 1m + 2% depth	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.
C	± 500m	2m +5% of depth	Full area search not achieved, depth anomalies may be expected.
D	Worse than ZOC C	Worse than ZOC C	Full area search not achieved, large depth anomalies may be expected.
U	Unassessed – The quality of the bathymetric data has yet to be assessed.		

Table 2.3.1 CATZOC Descriptions

Designating CATZOC values for charted areas is at least a partially subjective process; especially so when it comes to assessing legacy data. As a precursor to this research, a study was carried out to establish by what criteria CATZOC is being designated for legacy data by ENC producing National Hydrographic Offices [Harper 2010]. This research showed that there is significant variance in the way in which legacy data is designated with a CATZOC value. A consequence of this is that a mariner navigating across an ocean may be using data with the same CATZOC value, but be unaware that there are differences in the actual data quality.

2.3.3 Zone of Confidence Diagram

The zone of confidence diagram (figure 2.3.3) appears on some paper charts and delimits general areas of data quality in the same way that CATZOC does. As a consequence it suffers the same short comings as CATZOC with the exception of symbology and the ability to toggle it on and off.
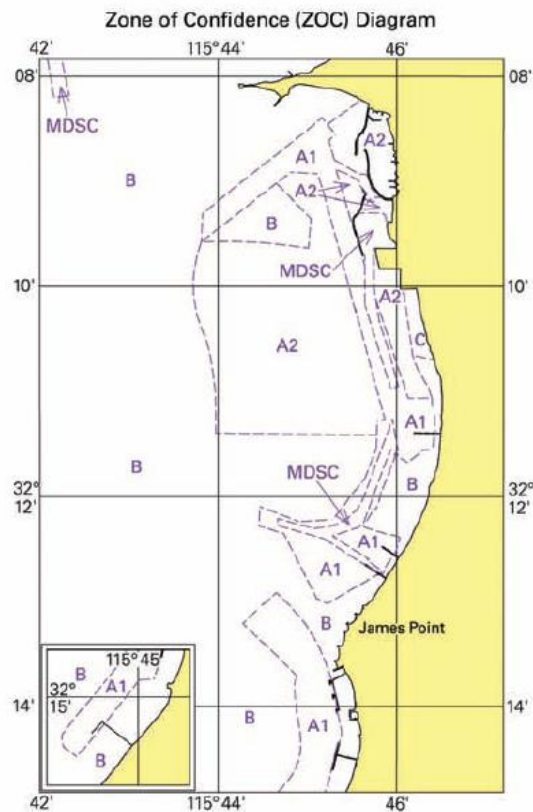

Figure 2.3.3 Zone of Confidence diagram

2.3.4 Data Quality Symbology

There are various symbols, legends and notes that supplement the information found in the source diagram or CATZOC display. These symbols and legends are often used to indicate data quality issues that relate to a specific feature, e.g. a reported depth note. For British admiralty products the mariner can find information on these symbols in BA NP 5011 (UKHO, 2004).

It is unknown how well understood the symbology that relates to data quality is. As it is entirely possible that users of nautical products are unaware of the relevance some symbols have in relation to data quality, this issue was explored in the questionnaire.

3. RESEARCH METHODOLOGY

The main investigative element of the study took the form of a questionnaire. The questionnaire was developed to support the aims and objectives of the project by facilitating the investigation of:

- The mariners' perception and understanding of data quality representation in navigation products

- The mariners' opinion of data quality education and information availability

- The mariners' preferences with regard to future methods of representing data quality in navigational products

The questionnaire was distributed by the IHO to member states, and was available as a PDF and an on-line version via surveymonkey.com. Over 600 responses were received, however due to time constraints the analysis was based on 574 responses.

A 'QUANqual' mixed methods approach was taken with the design of the questionnaire. The qualitative questions can be subdivided into two types:

- Those designed to elaborate on or give context to quantitative questions, e.g. 'other' and 'please explain your answer' free type fields

- Those designed to directly test the respondents' knowledge of data quality issues, e.g. 'what does the PA abbreviation mean?'

The qualitative analysis took the form of the identification of recurring themes and the ranking of these themes by their frequency of occurrence.

4. RESULTS

4.1 Demographics

In terms of the survey sample, the demographic information showed that 74% (421 respondents) had over 10 years navigational experience with 63% (357 respondents) having in excess of 15 years navigational experience. In addition, the results showed that a broad range of shipping sectors were represented. As a consequence, it is considered that a strong representative sample has been collected.

4.2 Paper Charts

Respondents who said that they use paper charts were asked whether the charts they use have either a source/reliability diagram or a zone of confidence (ZOC) diagram. The respondents that answered yes to these questions were then asked to indicate whether they use the information in

the source/reliability diagram or a ZOC diagram. Figures 4.2.1 and 4.2.2 show that 73% (296 respondents) of respondents use the information in the source/reliability diagram and 75% (82 respondents) of respondents use the information in the ZOC diagram.
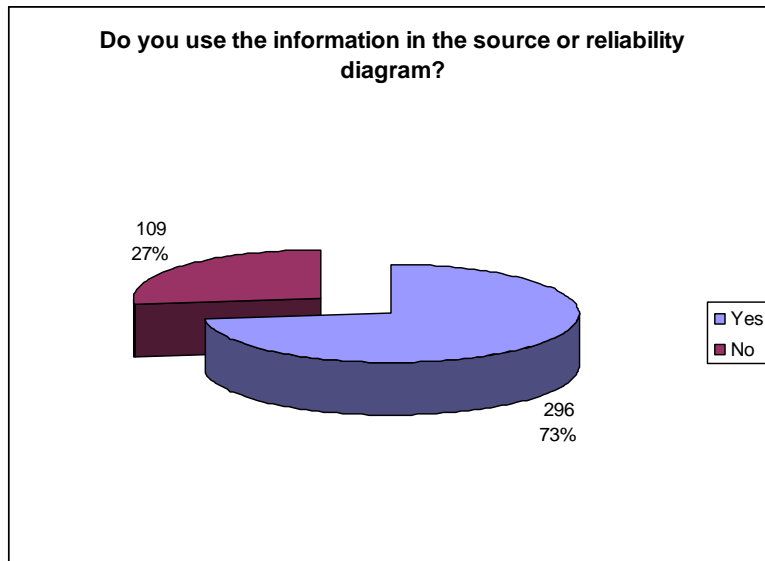

Fig. 4.2.1 Percentage of respondents that use the information in the source/reliability diagram
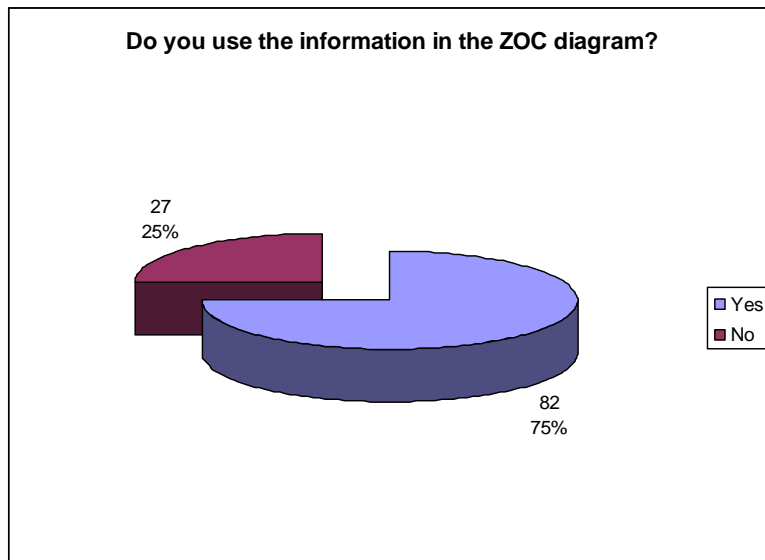

Fig. 4.2.2 Percentage of respondents that use the information in the ZOC diagram

Respondents that indicated that they did not use the information in the source/reliability diagram or ZOC diagram were then asked to explain why not via a multiple choice question. The most common reason chosen by respondents was "because I have travelled the same route many times before". A number of respondents selected the 'other' free type option and the themes arising from these answers are detailed in table 4.2.1. The most common reason cited was that "I trust that the charts are correct".

Theme	Rank
"I trust that the charts are correct"	1
"We are restricted by the Pilots limited area of operation and bow to their local knowledge"	2
"We rely upon experience and instruments instead"	3

Table 4.2.1 Themes and ranks for why respondents do not to use the information in the source /reliability diagram

Respondents were presented with a series existing data quality indicators that appear on paper charts and were asked to indicate whether they understood their meaning. Those that said they did were then asked to give an explanation of the meaning of the respective indicator. These answers were then marked as either correct or incorrect. Table 4.2.2 shows a summary of these results. Those figures coloured red indicate where the percentage of respondents who gave incorrect explanations is greater than 60%. The figures that are coloured amber indicate where the results were between a 41% to 59% split. The figures coloured green indicate that either the number of respondents who indicated that they understood the data quality indicator or those that gave a correct explanation exceeded 60%.

Data Quality Indicator	Do you understand the meaning of…?		Of those who answered yes, how many gave a correct explanation?	
	Yes (%)	No (%)	Correct (%)	Incorrect (%)
Broken depth contour symbol ?	56	44	73	27
Broken coastline symbol ?	66	34	69	31
Dotted danger line symbol ?	76	24	44	56
Discontinuity between surveys note ?	53	47	55	45

Data Quality Indicator	Do you understand the meaning of...?		Of those who answered yes, how many gave a correct explanation?	
	Yes (%)	No (%)	Correct (%)	Incorrect (%)
Unsurveyed note ?	88	12	94	6
Depths note ?	88	12	74	26
PA ?	62	38	98	2
PD ?	62	38	90	10
ED ?	62	38	82	18
SD ?	62	38	79	21
Rep'd (1999)	62	38	36	64
Sounding in an upright font ?	44	56	36	64
Discoloured water note ?	59	41	Corrupted	Corrupted
Sandwave symbol ?	64	36	91	9
Dredged to... note ?	98	2	98	2
Potentially dangerous wreck symbol ?	98	2	76	24
Bar above a dangerous wreck symbol ?	75	25	57	43
Works in progress legend ?	93	7	100	0

Table 4.2.2 Summary of results to questions relating to mariners' understanding of existing data quality indicators in paper charts

The criteria by which answers were judged to be correct or incorrect were very specific. This was because the aim of the question was to discover whether respondents fully understood the definition and context of usage of various data quality indicators, regardless of whether or not

their presence elicits a similar response. For example, a mariner might choose to avoid a sounding shallower than the draft of his/her vessel whether there is a 'Rep'd 1999' note attached to it or not; but if they omitted the condition 'but not confirmed' from their explanation of the 'Rep'd 1999' note, it may be the case that they do understand that it can be used in charting to indicate the presence of other unreported shoals.

It should be noted that due to an oversight in the design of the questionnaire, respondents were asked "do you understand the meaning of the Unsurveyed and Depths notes?" This has meant that the values for the first part of the question are the same for both indicators. However, respondents were given the opportunity to explain their meaning individually. Regrettably, the same situation occurred in the question relating to the PA, PD, ED, SD and Rep'd (1999) notes.

Generally the understanding of existing paper chart data quality indicators appears to be good, however the understanding of the 'dotted danger line symbol', 'discontinuity between surveys note' and the 'bar above a dangerous wreck symbol' appear to be marginal. Further, the respondents' understanding of the 'Rep'd (1999)' abbreviation and soundings in an upright font could be considered poorly understood.

The poor understanding of the 'Rep'd (1999)' abbreviation is attributed to the fact that answers not including the condition 'but not confirmed' were marked as incorrect. The question of whether a mariner would react to the Rep'd abbreviation in a different way to any other sounding is also raised.

The Sounding in an upright font was commonly misinterpreted as indicating that the value was in a different class of units (imperial or metric) to the rest of the data.

It was noted that the marking of these answers was a subjective process and as a consequence it is plausible that a different marker (from a different area of expertise) may generate slightly different figures.

4.3   ENCs

In contrast to the questions relating to source/reliability and ZOC diagrams, the results show that a large portion of ENC users (77%) do not use S-57 CATZOC (Figure 4.3.1). Further, sector analysis showed that the percentage is fairly stable regardless of number of years of experience.
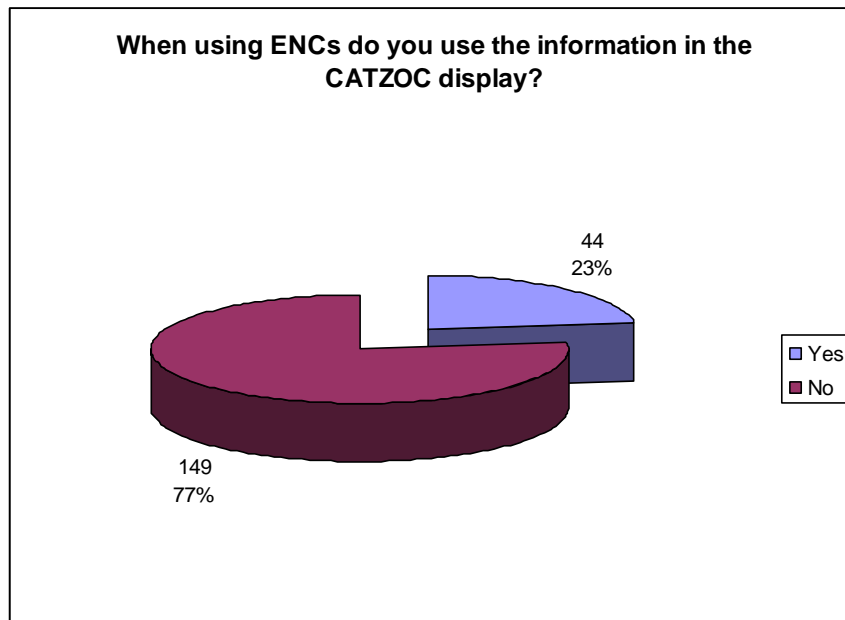
Fig. 4.3.1 Percentage of respondents that use the CATZOC display

As with paper chart DQIs, respondents were asked to indicate whether they understood the meaning of a range of S-57 data quality attributes. Those that said that they did were the asked to give an explanation of the meaning of the respective attribute. The results, detailed in table 4.3.1, show very poor understanding of the S-57 acronyms.

S-57 Attribute	Do you understand the meaning of…?		Of those who answered yes, how many gave a correct explanation?	
	Yes (%)	No (%)	Correct (%)	Incorrect (%)
HORACC	24	76	57	43
POSACC	29	71	60	40
SOUACC	31	69	91	9
VERACC	22	78	78	22
SURATH	42	58	91	9
SURSTA	32	80	94	6
SUREND	21	79	94	6

TECSOU	43	57	96	4
QUASOU	31	69	78	22
QUAPOS	27	73	79	21

Table 4.3.1 Summary of results to questions relating to mariners' understanding of existing S-57 data quality attributes

4.4 Wider Data Quality Issues and Future Developments

On the issue of training, 66% (183 respondents) indicated that they felt they had received insufficient training on data quality. This was reinforced by 78% (216 respondents) indicating that they would like to receive further training on data quality. The DQWG are currently investigating how training on data quality is delivered and what mechanisms for delivering further training to practicing mariners could be utilised.

Mariners were presented with a variety of conceptual future methods for representing data quality and invited to comment upon the various options. In general, respondents seemed to favour an on demand data quality colour overlay.

5 CONCLUSIONS AND SPECIFICATION

Analysis of the results has allowed us to draw the following key conclusions:

- A large proportion of ENC users are not using CATZOC information (77%)

- A large proportion (75%) of mariners that use charts with a ZOC diagram stated that they do use the information contained within it. This suggests that it is the digital application of CATZOC that mariners do not like, and that there is no clear preference for individual quality indicators over composites ones.

- The additional data quality indicator attributes available in S-57 data are not understood and not used.

- Whilst the results would suggest that mariners are aware of the relevance of understanding the nature of the seabed, it is not clear that they understand how an assessment or a designation of the quality of that information will change over time.

- A majority of mariners state that they have not received enough training on data quality issues, and that they would like to receive more training.

- There appears to be a preference for the clear delimitation of uniform areas of data quality. A high percentages of mariners indicated that they use the information in the source and ZOC diagrams rather than a CATZOC display. This was further supported by the results of questions on future developments which showed that the preferred option is an 'on-demand colour overlay'.

5.1   Specification for Developing New Methods of Representing Data Quality in ENCs

Using the results and conclusions from the questionnaire, the DQWG has developed the following draft specification for developing future methods of representing data quality in ENCs. These recommendations are meant to bring in new possibilities for implementation into ECDISs.

- As a minimum, the constituent elements of S-57 CATZOC (positional uncertainty, sounding uncertainty, features detected and seafloor coverage) must be encoded as separate attributes in S-101 ENCs,

- All encoded data quality information must be discoverable

- Temporal degradation of data quality should be reflected in the encoded data

- The portrayal of data quality should be able to reflect inputs such as dynamic tides, under keel allowance and vessel specific parameters.

- Where possible ENC attribute names that are available to the mariner should be more intuitive by avoiding such things as the S-57 6-letter acronyms.

- The portrayal of data quality should take into account the mariner's preference for an on-demand colour overlay

  Any method of portraying data quality should be accompanied by an appropriate education strategy.