

CHART DESIGN CONSIDERATIONS FOR THE NAVIGATORS OF TODAY AND TOMORROW

by A.J. KERR (*)

Regional Hydrographer, Central Region, Canadian Hydrographic Service

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INTRODUCTION

It must be emphasized from the beginning that the ideas and comments in this paper are those of the writer and do not represent any official view. Although the paper may at first appear to discuss some widely separated issues, its main theme is to examine the communications between the nautical chart producer and the chart user. In addition, it will extend itself beyond its title to examine this same mechanism, with respect to the other nautical publications.

The paper attempts to stimulate discussion. A potential danger for us all is that we become complacent, claiming that our methods or our products are the best. While self-confidence is desirable, complacency detracts from progress.

THE SHAPE OF THE NAUTICAL CHART

We may dream of using holography or cathode ray tube displays to provide chart users with three-dimensional and time-variable pictures of the navigational information. Realistically, at this time, we must consider the flat paper surface.

What we can show on the chart depends on the size of the paper, the scale, and the clarity of the cartographic presentation. Several writers [1], [2], [3], have addressed themselves to the matter of scale but no-one appears to have tackled the subject quantitatively on consideration of the

(*) *Author's note* : The comments in this paper are primarily directed to the methods now employed by the Canadian Hydrographic Service.

information content. Scale seems to be normally selected on the basis of the experience of the chartmaker bearing in mind the specific purpose of his product [4].

Admiral BAYFIELD is quoted [4] as saying that the scale should vary with the area covered by the chart and its particular purpose. "That of the Magdalen Islands for example, should be on such a scale that vessels could, by its aid, approach the islands closely and fearlessly in every part". PASCOE [5] writing in 1964 about British Admiralty Charts, states "Our policy is now to chart all coasts on a scale sufficient for coastwise navigation, this scale usually being about 1/300 000, and to chart foreign harbours accessible to ocean-going vessels. In home and Commonwealth waters where we are the national charting authority, we produce a large series of 1/75 000 in home waters, but generally 1/200 000 overseas for charts without complicated detail".

The choice of scale is associated with the choice of area and one of the prime distinctions between the land map and the navigational chart is that the latter cannot be schemed in a neat rectangular grid. In chart scheming an objective is to include useful reference points such as lighthouses or distinct radar targets, or ports between which he is likely to sail. Another feature is the overlap. Navigators, in projecting their course from one chart to the next, require an overlap. There has been considerable debate on the size of the chart frame. One school of thought maintains that it can be variable in size and take in a convenient area for the navigator. There appears to be a tendency today to favour a common size as the norm, departing from this as seldom as possible. In developing International Charts, a standard size of 841×1189 mm ($33 \frac{1}{8}'' \times 46 \frac{3}{4}''$) has been selected. This is known as the AO size. It has the interesting feature that folding does not alter the numerical ratio of length to breadth but simply reverses it each time it is folded in half.

The choice of projection has been debated in the past, but the considerable advantage [6] of being able to draw a rhumb line as a straight line has made the Mercator projection gain and maintain favour in most countries for medium and small scale charts. In Canada, many of the earlier charts were on the polyconic projection but today that projection is seldom used for nautical charts.

THE CONTENT OF THE CHART

It is possible that the shape of the chart has been examined in greater detail than the content of the chart. However, it is in the communication of information through the content of the chart, from the hydrographer to the user, that this writer sees some considerable room for improvement.

While we may admire the beautiful graphic quality of the chart of a century ago, it will probably be agreed by the majority of users that at times it is difficult "to see the wood for the trees". Over the last twenty years Canadian charts, along with many others, have tended to show less sounding figures and more depth contours. Indeed, the more radical

persons may suggest that the spot sounding depths are simply a carry over from leadline days. Perhaps the most recent step in that direction is the work carried out by ANDERSON [7] in developing a new design for a metric chart. One may wonder how far this trend will go. It is understood that contours were originally shown on charts as danger lines. In fact even today, the shipmaster will instruct his officer of the watch to "make sure you stay outside the ... fathom line".

Today the development of bathymetric charts, primarily as an aid to scientific studies, has shown how it is possible to use many and closely spaced contours to communicate rapidly to the beholder the shape of the ocean floor. A particularly interesting use of cartographic technique to show both "qualitatively" and "quantitatively" the seabed morphology can be seen in Japanese bathymetric charts. A blue coloured background is superimposed by black and white contours. The portion of a closed contour that lies to the south-east is black while the rest of the contour is white. This results in a notion of "hill shading".

Although colour has now been used for some time, its use has tended to be discrete. In Canada, it is of interest to note that on the navigation charts the shallows are shown as blue, and on the bathymetric charts the deeps are shown blue. Perhaps we should be more adventurous in our use of colour.

A topic that must be given an important place in this discussion is the methods used by cartographers to inform the user about the quality of the data from which the chart is made. During their training, navigators are told how to use the cartographers' "signs" to evaluate the worth of the chart. This writer suggests that these signs are altogether too subtle and that hydrographic cartographers must develop more specific mechanisms for communicating to the user the quality of the data from which the chart is made.

Vice Admiral Sir Archibald DAY writes [8]: "Chart users are advised in various ways and places how to assess a chart and stress is laid on the date of the survey quoted in its title". While the date may be used as a guide, it is certainly not fool-proof. In Canada, we are inclined to honour our predecessors by name and give credit to the modern hydrographers who may have substantially improved the chart by simply saying "Additions by the Canadian Hydrographic Service to 19..". For example, Chart 1207, Cap aux Oies to Grosse Ile (St. Lawrence River) says: "From Surveys by Cmdr. W.F. MAXWELL, R.N., 1885-86, C.M. SAVARY, 1918-19 and the Canadian Hydrographic Service 1971-72". Obviously this can be misleading as it is impossible to tell who did what. The writer has noted one example, Chart 4130, Petitcodiac River and Cumberland Basin, which covers this problem with a source diagram giving the dates of the various surveys used in the chart construction.

The most subtle technique used by cartographers to indicate the reliability, or perhaps the density, of the data is the selection of soundings. This technique has been examined carefully in some of the studies carried out as part of the cartographic analysis in preparation for automating cartography in Canada [9], [10]. We must emphasize that shoal soundings

are always selected first. The report [9], discussing the triangular mode of selection, states as follows: "This form of search and spacing is employed by compilers in survey areas; does not apply to track soundings areas". In discussing the selection of soundings in an inadequate survey area, it states "Soundings are selected to clearly indicate the existence of each track, which indicates to the mariners the possibility of an undiscovered shoal existing between the tracks". Finally, the report discusses track soundings. "When selecting soundings from tracks be sure that the linear characteristic of the track is preserved — this will prevent an area in which there are many tracks from appearing as though a normal, adequate survey has been conducted!".

To point out the fallacy of using this technique as a sound method of communication, the writer will relate a story that he was told (admittedly hearsay) about an icebreaker captain. This shipmaster, on examining a chart that was on the frontier of hydrographic progress, noticed that he had a choice of two channels. One channel was shown with a mass of soundings all in converging and crossing lines. The other channel was shown with very few soundings but they were placed in a neat geometrical pattern. Thinking back to those distant days at navigation school, he remembered being told that a scarcity of sounding indicated a poorly charted area — so he took his multi-million dollar ship through the channel with lots of soundings!

Another example, which is perhaps more important, is a statement made by Captain OUDET [11], a most respected French navigator and hydrographer. In discussing the grounding of a French cruise ship and the reliability of the chart, he states "An examination of the chart shows that it was based on surveys, the scientific character of which remains valid today. In fact, it shows the regular lines of soundings that are recognised in the nautical literature as evidence of careful hydrographic work".

It seems that the cartographer is not communicating as well with the user as he thinks he is. This writer proposes that the user be told much more clearly just how good the chart is. One possibility is suggested by OUDET himself, who notes [12] that it took him twenty-three years to perceive the answer and that was to make a critical appraisal of each chart in the *Sailing Directions*. Another method, which until recently was used more by geologists than hydrographers is the accuracy (or data source) diagram. A very small number of Canadian charts, mainly in the Arctic, contain these diagrams but they are styled more to tell other hydrographers about the data than to enable the user to evaluate the reliability of the chart. The Australians appear to be taking a progressive approach to reliability diagrams as evidenced by their recent article in the *International Hydrographic Bulletin* [13]. This matter is now being studied by the Canadian Hydrographic Service.

In the Arctic, there is a particular need to show the user the quality and density of the data. The data comes from a variety of sources; icebreakers, random commercial vessel tracks and proper surveys. Source diagrams are essential. The trend towards corridor surveys on the Labrador Coast, James Bay and elsewhere will need some better indications to the navigator than the selection of soundings can show. Corridors will probably

need to be outlined clearly on the charts themselves with a pecked line or some cartographic method of defining a boundary.

Consider now the traditional representation of bottom type. Obviously, this is a carry-over from the days of arming the leadline. In many places today, very good geological information exists and where it does not exist, we can either use the sidescan sonar or make a careful analysis of actual echo soundings as described by MONAHAN [14] to provide this information. Geologists show the surficial features by means of polygons identified with a symbol or abbreviation. In fact, in the new Canadian prototype fisheries map, the bottom features have been shown in this manner. We should examine whether or not bottom type could be shown more effectively on the standard navigational chart in this way.

CATERING TO OUR CUSTOMERS

The wealth of detail on the nautical chart allowed it to stand the test of time as the users became more and more diversified. Unfortunately, there comes a time when a product can no longer satisfy all its customers and specialized products must be made. The responsibility of the Canadian Government to develop new products is a debatable point as it becomes questionable whether it is improving its authorized service to the community or infringing on the rights of private industry. However, that matter must not be debated here. In terms of numbers, the largest user of nautical charts in North America today is the recreational boater. Recognizing this in 1958, the U.S. Coast and Geodetic Survey, under its Director, Rear Admiral KARO, moved to satisfy this new customer. BRUDER [15] describes the study leading up to the introduction of the new product, and it is a model of how an agency should go about its "new business". There was a well controlled statistical survey of the users, using samples of different cartographic approaches to the new products. A full advertising campaign was put into effect and the response to the first production copies was clear evidence of a successful launching.

Canada, which probably has an unusually high ratio of recreational boaters to commercial shipping, followed the U.S.A. Its approach was more experimental, producing first charts in book form of the Athabasca and Slave Rivers (for barge and not recreational traffic) and the Kootenay Lake. Finally it entered the truly recreational chart field in 1964 when it produced its first small craft charts in accordion-folded strip form of Georgian Bay. These charts were particularly interesting in that they attempted to maximize the information shown to the user both on the water and on the land by showing the land as a photo-mosaic. This last frill was not continued as it proved difficult to maintain and was not greeted by any particular enthusiasm by the users.

The program of small craft or recreational charting has continued, with attention being given to many of the inland waterways such as the Rideau, Trent and Ottawa Rivers which had not been previously charted in any detail. In these areas, the accordion-folded strip form has continued

to be used. In the Lake of the Woods, Rainy Lake, Muskoka Lakes and Lake Kejimikujik in Nova Scotia, charts of normal dimensions have been used. Latterly small craft charts have been produced on the Pacific Coast covering an area where the regular navigation charts are also maintained for the navigation of commercial traffic.

Changing traffic patterns in the Great Lakes are causing hydrographers to question the existing type of chart. Commercial shipping, which had previously called at many small lake ports, is now concentrated on the major ports and, in the Lower Lakes at least, travels mainly along the axis of the lakes. On the other hand, recreational boating has increased tremendously, in particular in centres such as Toronto, Kingston, Buffalo and Chicago. This traffic concentrates in these areas and when making passage most of it is close to the lake shores and only occasionally crosses the lakes. In order to respond to these traffic changes, we should consider producing strip charts along the lakeshore as the Americans have already done in Lake Michigan, near Chicago. It might then be possible to cancel the existing "square" charts which were designed for commercial traffic. Naturally smaller scale charts of each lake would still be required together with regular navigation charts of major ports.

Another area in which a more suitable product might be provided to the user are the charts of plans that exist for many of the minor ports in the Lower Lakes. The normal yachtsmen, entering one of these ports, is obliged to fold the large chart of plans until he has it in a manageable size exposing the port of interest. A more suitable product for these users would be an accordion-folded chart or possibly a book of charts which he could hold in one hand, while he held the tiller in his other hand and the mainsheet in his teeth!

This leads into the subject of written information; although Small Craft Guides have been produced that are some small improvement on the Sailing Directions, they also need to be consulted during the sometimes difficult operation of entering one of these small ports. It may be better if this information and that given on the chart is provided in one document, namely a book of folded charts with the chartlet on one page and the description of the port on the facing page. Perhaps the addition of an oblique photograph of the port approaches would complete a package that the user could in fact "use", with a force 8 gale abaft the beam and a breaking sea beneath his counter.

The possibility of replacing standard navigation charts with small craft charts may be worth examining in the interest of our chart correction procedures. These are being studied at present, and it has been noted that while we always correct the standard charts, the small craft charts are not corrected by hand.

SAILING DIRECTIONS

Earlier in this paper, it was suggested that the Sailing Directions could be used to provide the mariner with an evaluation of each chart. It was suggested in the last paragraph that a combined form of chart and port

description might assist the small boater. What should Sailing Directions be like? How can they be most suitably designed as a medium for communication between the hydrographer and the navigator?

Two years ago, the Canadian Hydrographic Service made a significant change in the Sailing Directions [16]. Using, in part, the excellent studies carried out by the U.K. Hydrographic Office and the U.S. Naval Oceanographic Office, Canada made major changes in the content, format and method of production of these volumes. A general information chapter was introduced, oblique aerial photographs were included, and an attempt was made to remove some of the duplication that existed between chart and written descriptions. Automation was introduced and, consequently, the volumes are reprinted more frequently and supplements are no longer used.

It appears to this writer that while this was one positive step, the Canadian Hydrographic Service is far from the top of the ladder. The inherent conservativeness of mariners and hydrographers, which is at the same time their strength and their weakness, has prevented the duplication between chart and Sailing Directions from being properly removed. The stated reason was to emphasize the dangers. This writer suggests that the clutter of words, in obscuring the really significant information, represents far more danger to the navigator.

To illustrate this important point, the writer will use the example of a randomly opened page of the Gulf and River St. Lawrence volume, First Edition, 1973, Chapter XIV. The first column of the first page refers to Chart 1201. It starts by stating that the St. Lawrence River between Ile Verte and Cap aux Oies is divided into two navigable channels, known as the North and South Channels, a fact that is perfectly obvious from the chart. The column continues in this way and it is submitted that there is not one piece of information that cannot be read from the chart or List of Lights!

Reading on through the chapter, interesting pieces of information can be found. For example, we find that there is a temporary anchorage for small craft at Port aux Quilles, and that there is electricity, fresh water, telephones, accommodation, to be found at Saint Simeon Wharf. Unfortunately, all the useful information is obscured by a welter of descriptive information that can be obtained just as easily from the chart.

It appears that another examination of the Sailing Directions should be made, aimed at complete removal of information that can be found on the chart. At the same time, there must be much more useful information that cannot be found on the chart and that could be added to the Sailing Directions.

For example, it might be useful to tell the navigator that while the large traffic is made up mainly of large lakers and containerships travelling in the North Channel, small pulp boats move around the river in various directions and are often equipped with inoperative radars.

It must be stated that these comments are not just directed at the writers of these volumes but also at those who provide the information. The Sailing Directions, like the charts, are only as good as the surveys from which they are made.

CONCLUDING REMARK

Many "sacred cows" have been fired at during this discussion but we must continually examine our products and our service, or we die.

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