International Hydrographic Review, Monaco, LVI (2), July 1979.

BACK TO COOK — THE ROLE OF THE HYDROGRAPHER IN DELINEATING TOPOGRAPHY AND CULTURE

by C. G. CHAMP
and P. WARREN
Canadian Hydrographic Service, Ottawa

Paper presented at the 17th Canadian Hydrographic Conference held 18–20 April 1978, Patricia Bay, Sidney, B.C., and reproduced here by kind permission of the Conference organizers.

INTRODUCTION

The concepts for this paper were formulated during the period April 1975 to March 1976 when I was a member of the Chart Presentation Steering Committee of the Canadian Hydrographic Service (CHS). This Committee, under the chairmanship of the late E.M. WALSH, was charged with the task of developing a new presentation for Canadian charts to meet the needs of metric conversion and bilingualism. A third requirement was to ensure that where practicable the presentation would agree with the international chart specifications then under development through the North Sea International Chart Commission (NSICC).

The initial work of the Committee focussed on methods of showing bathymetry and chart scheming as described in papers given in 1976 [1] [2]. Subsequently a decision in principle was reached on the basic concepts to be followed in showing topography and culture on Canadian charts. This paper reviews the historical evolution of how land features have been shown; comments on the inadequacies of the current presentation, then explores the new philosophy and compares it with that developed by the NSICC.

Definitions

The features shown on the land areas of charts are of two types:

Topography: the contours, peaks, saddles between peaks, gullies, cliffs, nature of the shoreline, rivers, lakes, glaciers, etc., required to permit the mariner to visualize the shape of the land and nature of the coast he

can see from seaward and to identify prominent summits, ridges, etc., which he can use to position his vessel either by visual bearings or by radar bearings and ranges, or by a combination thereof, or by establishing clearing lines and transits.

Culture: the man-made additions to the landscape such as roads, railways, and conspicuous buildings such as churches, towers, domes or other buildings, etc.

HISTORICAL DEVELOPMENT

A direct line in the development of Canadian hydrography can be traced back to 27 July 1758, the day after the surrender of Louisburg, when James Cook,

> "... the master of the *Pembroke* was ashore at Kennington Cove... His curiosity was much aroused by the behaviour of a man carrying a small square table, supported by a tripod; the man would set his table down so that he could squint along the top in various directions, after which he would make notes in a pocket-book... He was a military engineer; he was making a plan of the place and its encampments, his name was Samuel Holland" [3].

That meeting laid the foundation for Cook's career as a hydrographer and explorer. Cook expressed an ardent desire to be instructed in the use of the instrument and Holland agreed. Cook produced his first chart of Gaspé Harbour that fall but it does not show any land features. During the following winter Holland worked with Cook compiling the charts to be used when the fleet sailed to beseige Quebec. He also assisted Cook to master the intricacies of spherical trigonometry and astronomy, so this really was Cook's apprenticeship as a hydrographer. In 1759 Cook played a major role in surveying the approaches to Quebec, especially the Traverse below Ile d'Orleans from which the French had removed all the navigation marks.

After the war was over Cook was chosen to start the first regular surveys of Newfoundland. In BEAGLEHOLE's judgement,

> "Cook was to carry out many accomplished pieces of surveying, in one part of the world or another, but nothing he ever did later exceeded in accomplishment his surveys of the southern and western sides of Newfoundland from 1763 to 1767... He was so successful because he could deploy all the technique he had acquired from the military 'engineers'; because he could work at times on land as well as from the sea." [4].
>
> The large charts are indeed tremendous productions: the 'exact trigonometrical survey' of the west coast is about ten feet long, on an inch to the mile scale, and includes much inland topographical drawing, ... This was raising British hydrographic surveying to a new power.

> ... the distinctive characteristic of Cook's manuscripts, it has been said, is the care and fullness with which topographical detail on land is drawn, a good deal of brown and green brushwork marking relief landcover, in the manner of military mapping. Cliffs appear in semiprofile, an old convention." [5].

A portion of the chart of the west coast of Newfoundland is shown as figure 1. It will be seen that Cook besides showing the areas of high land also made considerable use of views of the coast.

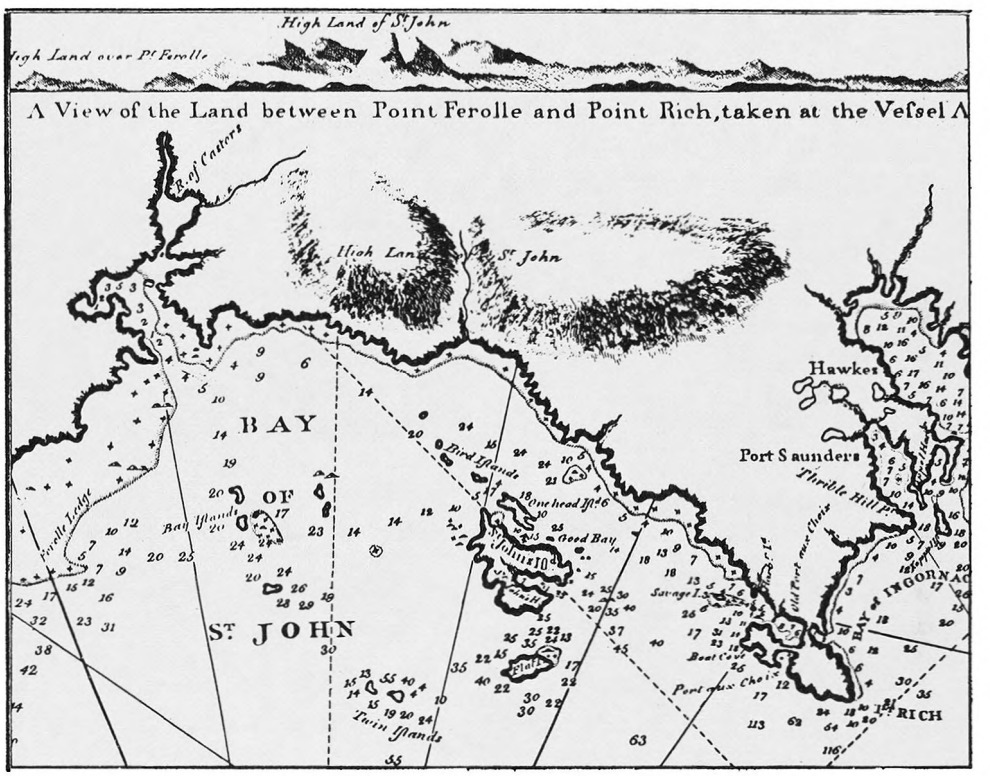


FIG. 1. — "A Chart of the West Coast of Newfoundland, ... by James Cook, Surveyor", 1769. Scale 1/72 000 approx.

Over the next century the depiction of topography became an art form in its own right, as shown in figure 2. This is a portion of Chart 4669, Red Bay in the Strait of Belle Isle, surveyed by the Admiralty in 1890. In fact, as can be judged from the oblique air photo on page 317 of the Sailing Directions, Newfoundland, fiith edition, 1977, the topography is probably exaggerated since the highest hill is only 497 feet.

Figure 3 taken from Canadian Chart 1204 surveyed by Lt. Miles, R.N., and Mr. Savory in 1907-9, showing a portion of the Lower St. Lawrence, is in my opinion an almost ideal representation. It is economical in effect but presents the mariner with the critical information he needs. Figure 4 (a) from chart 4714 surveyed in 1951 probably comes close to the nadir of the hydrographer's contribution with its use of "pimples" to show a

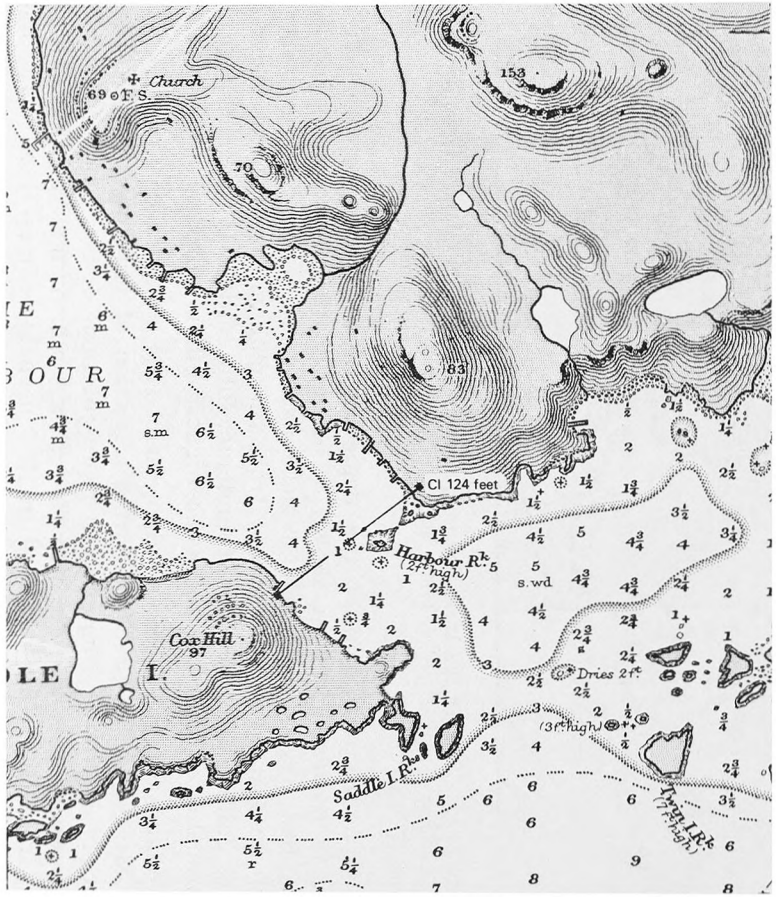


FIG. 2. — Canadian Chart 4669, Red Bay, Surveyed 1890. Scale 1/12 000.

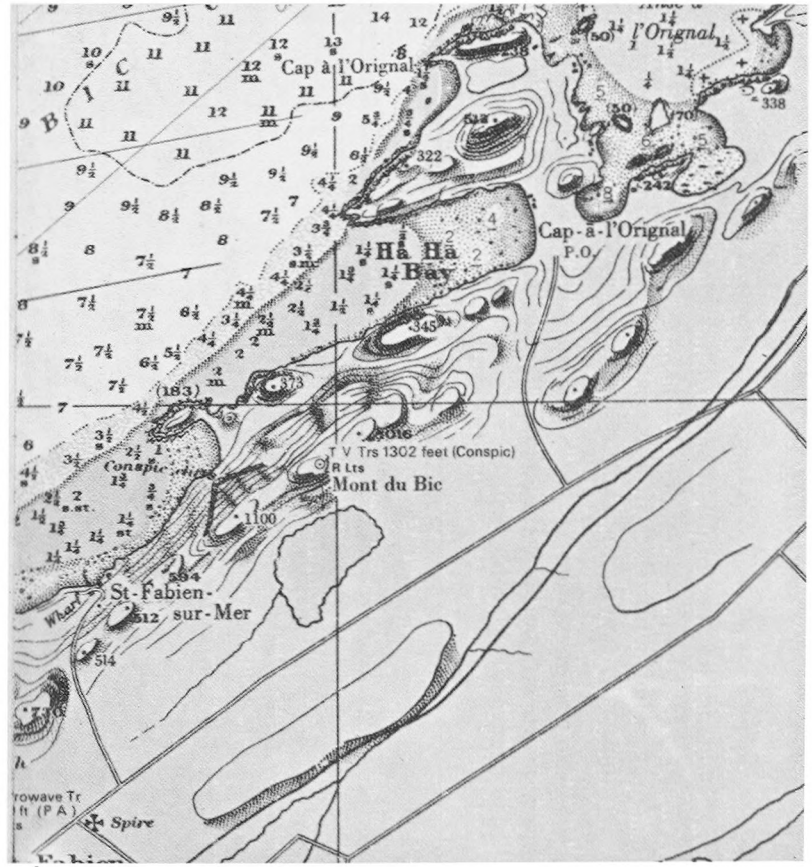
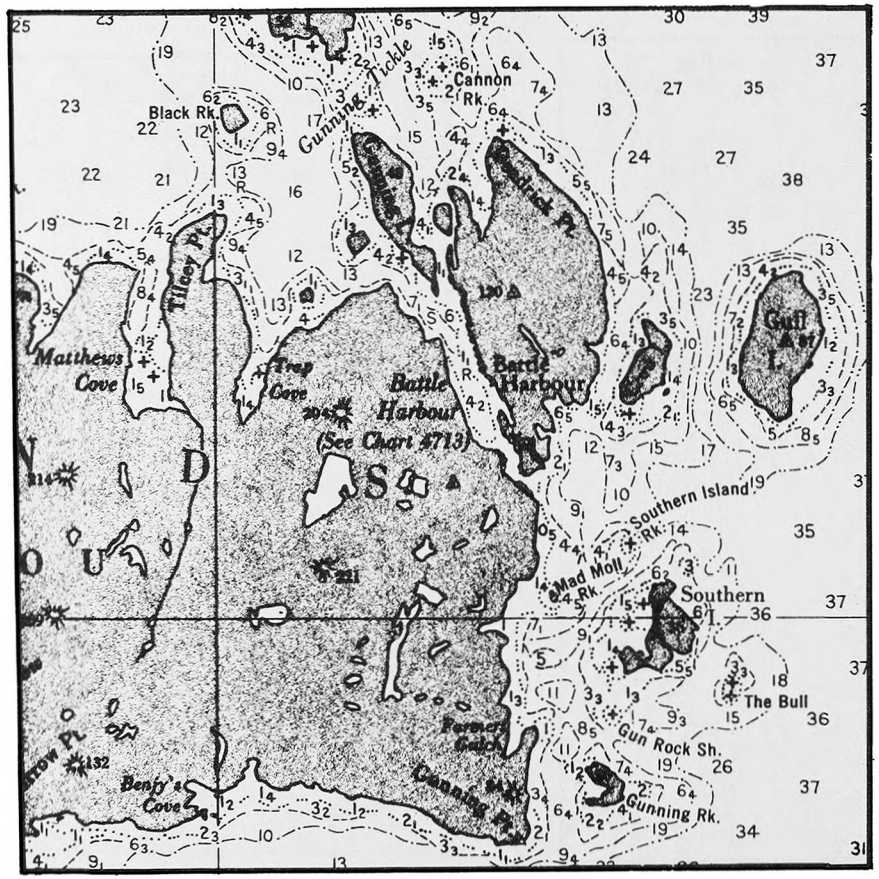
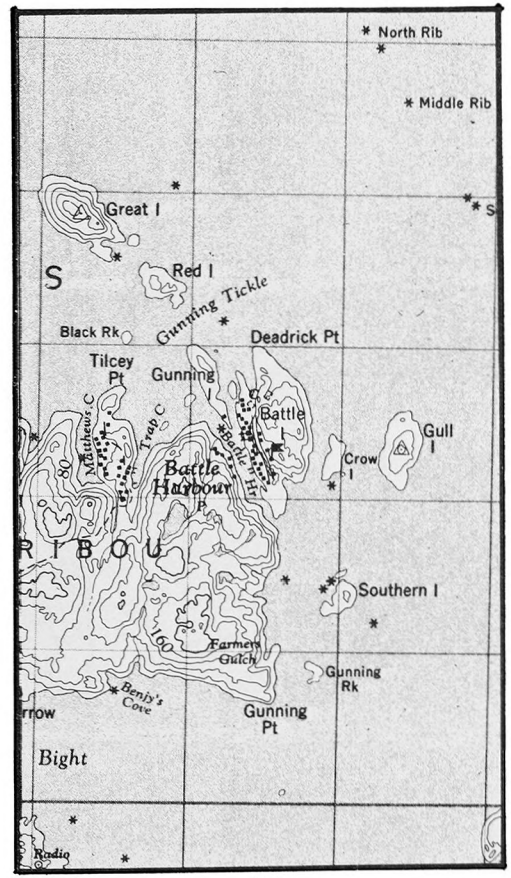


FIG. 3. — Canadian Chart 1204, Ile du Bic to Ile Vert. Surveyed 1907–8. Scale 1/77 800.



(a)



(b)

FIG. 4. — a) Canadian Chart 4714, Cape St. Charles to St. Mary's Harbour, Surveyed 1951. Scale 1/25 000. b) Canadian Topographic Map 3D/5E, Fox Harbour, 1/50 000. Edition 1, 1965.

series of isolated high points. How far this is from a good presentation can best be judged from figure 4 (b) showing the topographic map of the same area.

From the early 1950's onwards topographical maps at scales of 1:50 000 and 1:250 000 became increasingly available, and the hydrographer rapidly stopped showing land information on his field sheets and the compiler added it to charts, usually to their full limits, from the topographical maps. I think it can be shown that this has lead to a degradation in the information available to the mariner and at the same time has increased the drafting work, to the point where on some charts the land information accounts for up to 75 % of the time spent drawing a chart.

Figure 5 is taken from chart 3450 as it existed before 1968 when the topography was drawn by the hydrographer, and figure 6 shows the current

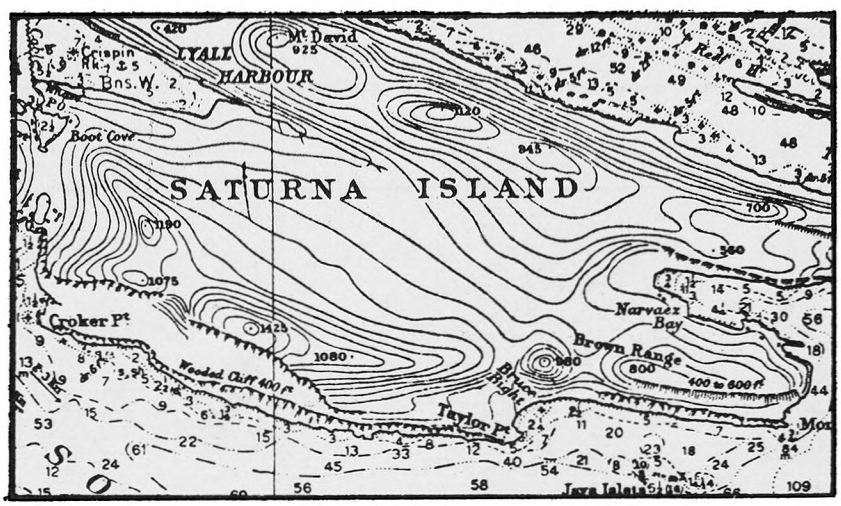


FIG. 5. — Chart 3450, East Point to Sand Heads, published 1937. Scale 1/80 000.

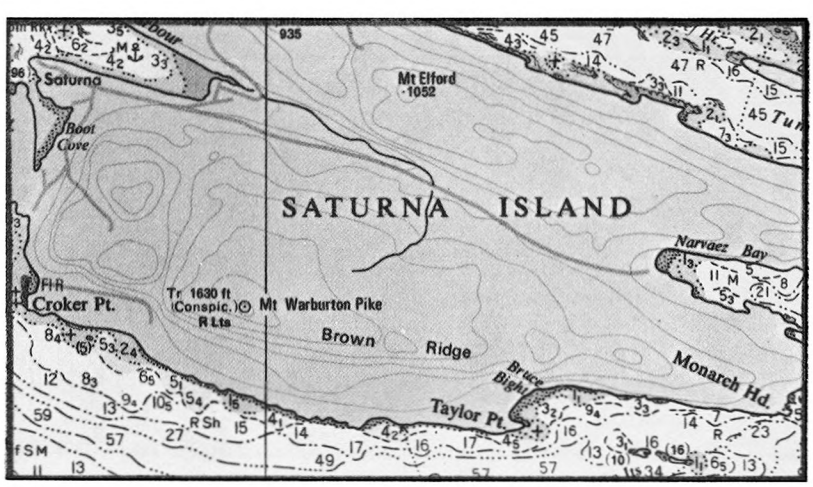


FIG. 6. — Chart 3450, East Point to Sand Heads, 1968 Edition. Scale 1/80 000.

edition compiled from topo maps. I think that it has to be agreed that the earlier chart, with its use of the cliff and steep slope symbols, presents a far more accurate picture of the terrain than the bland, rather rounded appearance of the later chart.

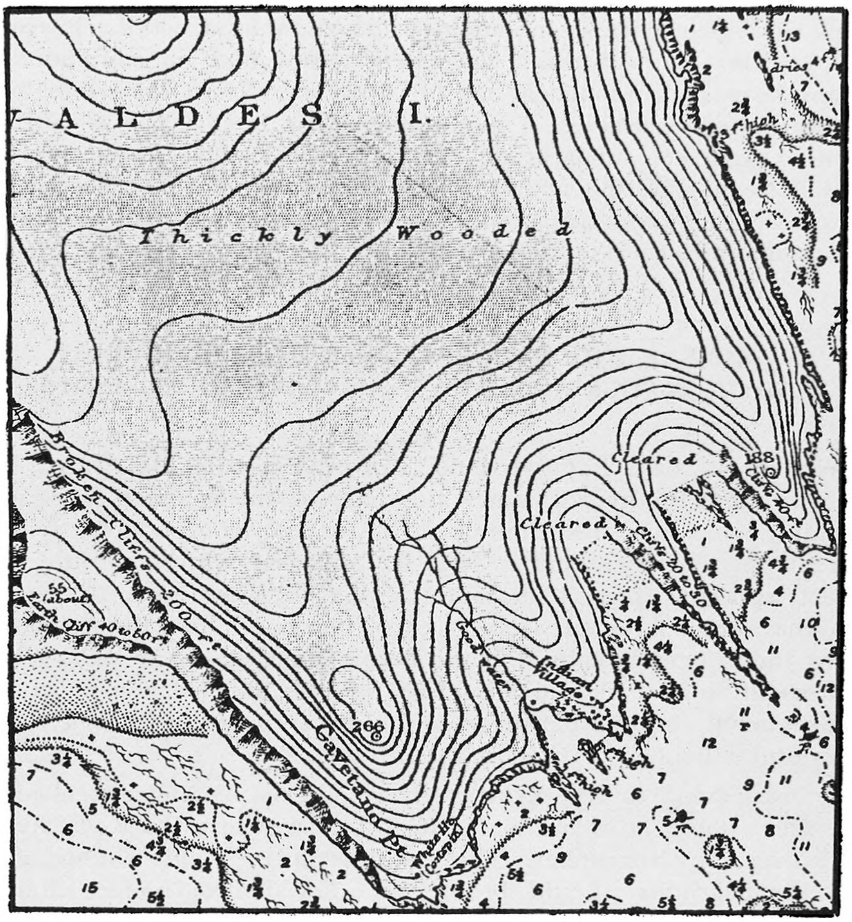


Fig. 7. — Admiralty Chart 3574, Porlier Pass, Surveyed 1905. Scale 1/12 000.

Similarly figure 7 shows the plan of Porlier Pass as surveyed in 1905. The present plan shows no topography at all ! The cartographer thought it would be bad practice to enlarge the 1:50 000 topo map four times to the 1:12 000 scale of the plan. He therefore preferred not to show any topography at all ! Surely a bad error of judgement. It also ignores a very significant fact — the mariner is rarely interested in the absolute accuracy of topography, he is interested in general shape. The only time that a mariner wants an accurate height is when he is judging at what distance off he can expect to see a feature, either visually or by radar. It also overlooks the ironic fact that, although maps are prepared in photogrammetric plotters, where the photogrammetrist has a complete birds-eye view of the ground, topographic contours are only specified to have an accuracy of plus/minus 50 % of the contour interval ! The hydrographer

even though he is working through the opaque medium of water strives, and in critical depths certainly has to do better than that !

One experimental presentation was used on our first three small craft charts 6301, Athabasca River, 6302, Slave River, 2303 Parry Sound to Byng Inlet, and one standard chart 2042, the Welland Canal. This was the use of a mosaic of air photographs to show land detail. These charts aroused little comment when they were issued and no complaints when the mosaic was abandoned at the next edition. From the users' point of view the biggest weakness of a mosaic is that it only shows culture and vegetation and not topography. Also, probably even fewer chart users are used to interpreting an air photo than a map. From the producer's point of view the major objection is that the only way to update the mosaic is to obtain new aerial photography.

ROLE OF THE HYDROGRAPHER IN DETERMINING WHAT TOPOGRAPHY AND RELIEF SHOULD BE SHOWN

In view of these imperfections, and others to be illustrated later, it is apparent that the hydrographer must once again be much more involved in deciding what land information should be shown on charts. It is therefore proposed that field parties will be supplied with a mosaic showing the best available topographic information for the limits of each chart which they are surveying or revising. This should be annotated, in red to show the information that should be emphasized and in yellow to show the information that should be deleted on the finished chart. In making this assessment the hydrographer should seek the assistance of the ship's officers and others.

Before leaving for the field a review of existing and cancelled charts of the area should be made to see if any exist where the topography was compiled by a hydrographer. These will usually provide a good guide as to what topography should be shown. The hydrographer should also discuss with the Chart Production Chief and consult the Chart File to determine the source of the shoreline on existing charts of the area. Especially in northern waters it will only occasionally be found that the shoreline on existing charts originally published before 1960 is derived from mapping tied to the North American 1927 datum. Northern Canada was only covered by trimetrogon photography in the period 1944-1950 and the resulting planimetric plots underwent a series of adjustments as the control networks were extended slowly northwards. The 1:250 000 mapping was only completed in 1967, and small changes can be expected as the 1:50 000 coverage is extended.

Where no previous charts exist, and for the cultural information to be shown, the hydrographer should be guided by the guidelines to be described.

THE MARINER'S REQUIREMENT

In their discussions the Chart Presentation Steering Committee agreed that the only topographic and cultural features to be shown on a chart should be limited to those which the mariner needs to:

1. Using visual and/or radar fixes, make a safe landfall upon unknown coasts to avoid all dangers, and to safely enter a harbour. In an emergency, the mariner may have to decide very rapidly where he could most safely beach his ship or the best direction in which to seek help. Medium scale charts are usually used for these purposes.
2. Manœuvring and docking within a harbour by reference to conspicuous features using large scale harbour plans, to conduct harbour business as efficiently as possible by having a knowledge of dock areas and the location of various offices and facilities.

Any information which is not needed for one of these purposes is redundant and should not be shown. However, it must be remembered that the chart has to serve the needs of a wide variety of users ranging from large commercial ships to fishermen and yachtsmen. It is important that the topographical information shown meets the needs of all these users, be it the navigator of a bulk carrier or warship equipped with a variety of sophisticated electronic positioning devices, or the recreational yachtsman relying solely upon basic visual observations. In fact it is the navigator of a yacht or fishing vessel who will make the most use of transits of headlands, islands and topographic features. It is he who, under adverse conditions, such as seeing a coast for the first time or intermittently through a fog, will need to use all the clues given by studying the topography carefully to locate his position.

Information required at different scales

1) *Large scale charts*

It is felt that it would be enough to show the limits of built-up areas plus the buildings back to the first street line, together with the customs house, office of the medical officer of health, the post office, nearest hospital, the harbour masters or other port authorities office, etc., and enough of a street plan to enable them to be located. The conspicuous objects that may be used by the mariner in accurately positioning his ship while manœuvring to anchor or berth must all be shown on the chart, remembering that the mariner will prefer to use those closest to him rather than those far off. However, this may not always be possible, for on misty mornings objects close to the water front may be obscured while those at a higher elevation may be visible. Features of navigational interest such as permanent tide and water level gauges will be shown even though they are not visually significant. In major harbours there are usually sufficient conspicuous cultural features to enable the mariner to position himself, so the amount of topography to be shown by contours can be held to a minimum.

This is very close to the NSICC preferred representation which is:

> "reasonably full details of roads and buildings in dock areas and adjacent to the coastline generally, to the extent that a mariner unfamiliar with the port gets an indication of the layout of the port and access to shore facilities of general maritime interest. Full depiction of landmarks is required but surrounding built-up areas need not necessarily be shown" [6] (Para. 320).

2) *Largest scale continuous coastal series*

The NSICC states the requirement for cultural information well:

> "Inshore navigation requires the navigator to pay constant attention to his precise position, often by visual means, because of the danger of running aground. Natural features close to the coast are most important on this scale". (Para. 350.2).
>
> ". . . Roads, railways and even minor tracks running down to, or along, the coast, buildings near the coast, and all tall structures which may be visible should be charted to assist identification of position, usually by visual means. At night the limits of the built-up areas are particularly important because, at such times, the lights of navigational aids may be difficult to identify in the vicinity of a well-lit urban area." (Para. 360.2).
>
> "Airfields within a few miles of the coast shall be charted on large and medium scales; they are significant to coastal navigation because of the many visual and aural features associated with them and the related air traffic." (Para. 366).

On charts providing the largest scale continuous cover, sufficient formlines shall be shown to enable the mariner to positively identify the topographical features and also the conspicuous objects visually or by radar. On these charts all possible information should be shown on the nature of the coast—does it have high or low cliffs, is it marshy, is there a rocky foreshore, or a sand or single beach? The mouths of all rivers and streams should also be shown as they have some influence on the waters into which they empty.

Topography

The chart must show the mariner by the use of contours, or the cliff symbol, the topographic features which he can use for radar or visual fixing, without confusing them by showing features which he cannot see and therefore cannot use. As a general rule no topography, except for the courses of major rivers, should be shown on charts unless it shows an area which can definitely be seen from somewhere to seaward on that particular chart. The topography to be shown is that of most use to a mariner navigating the coast for the first time. Therefore the first impressions of the coast may be more valuable than those obtained after considerable familiarity when minor inconspicuous features assume an importance for a particular purpose.

It is proposed in future that all contour lines derived from topographical maps be treated as form lines and not be labeled. This is partly due to the fact that it will be many years before topographic maps showing metric contours are available for all of Canada. Therefore we will be using contours which are not at standard metric intervals. More important, there is a consensus that far fewer contours are required than we are now using to show the shape of the topography. The NSICC specifications state that,

> "Ideally the coutour interval should be chosen so that fewer than 10 contours are needed for the full range of height on a single chart or particular series of charts (for clarity and economy)." (Para. 351.4).

There is one point on which our thinking diverges from that of the NSICC. The preceding quotation starts,

> "The contour interval shall be uniform for any chart, or series of overlapping charts on the same scale, except that the lowest contour may be a *supplementary* one . . ."

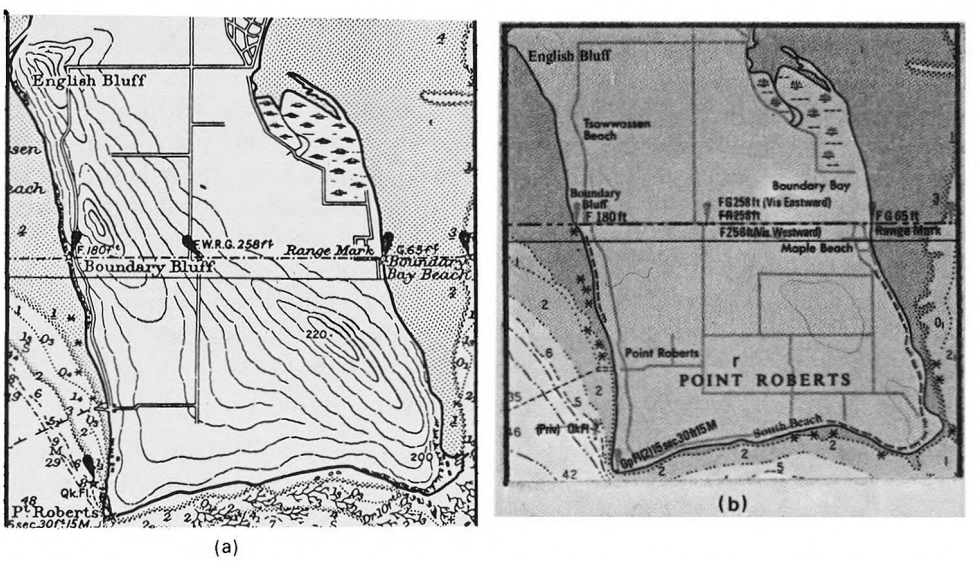


FIG. 8. — a) Admiralty Chart 576, Strait of Georgia: Alden Bank to Nanaimo, 1952, 1/76 500. b) Canadian Chart 3450, East Point to Sand Heads, 1968, 1/80 000.

Figure 8 shows two examples of the charting of Point Roberts. This is a portion of the same chart as figures 4 and 5. This is a case where on one side of the Strait of Georgia the relief is of the order of 5 000 feet while on the other side it is only 250. Anyone who has stood on the ferry as it leaves Active Pass and heads for Tsawwassen would to agree that English Bluff behind the ferry terminal is a significant feature even though it is a mole hill compared with the mountains and hills behind you on Vancouver Island. This is another good illustration where the old chart, figure 8 (a), in this case Admiralty Chart 576, is far superior in its depiction of topography than the modern Canadian chart, figures 8 (b), which relies on one 250 ft contour taken from topo maps.

Spot Heights

Spot heights of summits, and the top of cliffs, are important as they enable a mariner to predict the distance at which he may see the object visually or on radar. Therefore many more spot heights are to be shown than has been our practice. Many features, such as tapering mountain summits, can be seen a long way to seaward, yet will not be visible on radar due to the land formation. As extreme accuracy is not important, where no height is given on either the field sheet or topo map, it should be estimated by adding half the contour interval to the height of the nearest contour. Where a spot height is derived in this way, no dot will be shown. More preferably, the hydrographer should obtain an accurate height by survey. The Canadian Hydrographic Data Centre has on file many of the compilation drawings for the 1 : 250 000 maps of the Arctic. These are at a scale of 1 : 125 000 and the sheets of the outer coast have 100 ft contours. This would enable more accurate spot heights to be derived than from the published maps which only show 500 ft contours.

Cliffs

One of the topographic features on which the CHS has allowed itself to be too heavily influenced by topographic maps is the use of the cliff symbol. In Europe, hill shading and rock drawing is regarded as the highest expression of the cartographer's art. In Canada, probably under the influence of engineers, the cliff symbol rarely appears. Figure 9 shows a general analysis of the coastal landforms of Canada, excluding the Queen Elizabeth Islands. This clearly shows that cliffs are the predominant landform, yet these are not shown on our main source document. Another odd point is that no technical definition of a cliff appears to exist!

The NSICC specifications are extremely lucid on this subject,

> "A Steep Coast, i.e., a coast backed by rock or earth cliffs, gives a good radar return and is useful for visual identification from a considerable distance off, where cliffs alternate with low lying coast along the shoreline. Where cliffs are prominent features they should be charted on scales larger than 1 : 500 000 generally; as an exception, where cliffs predominate over extensive stretches of coastline, it may be neither feasible nor particularly useful to insert a cliff symbol throughout. Cliff-top heights are useful for calculating or estimating distance off, (for clearing inshore dangers) and should be shown where possible.
>
> A steep coast shall be represented by the accompanying symbol, with the cliff crest in its true position of the largest scales. On medium scales the crest may have to be displaced inland slightly for the symbol to be drawn clearly.

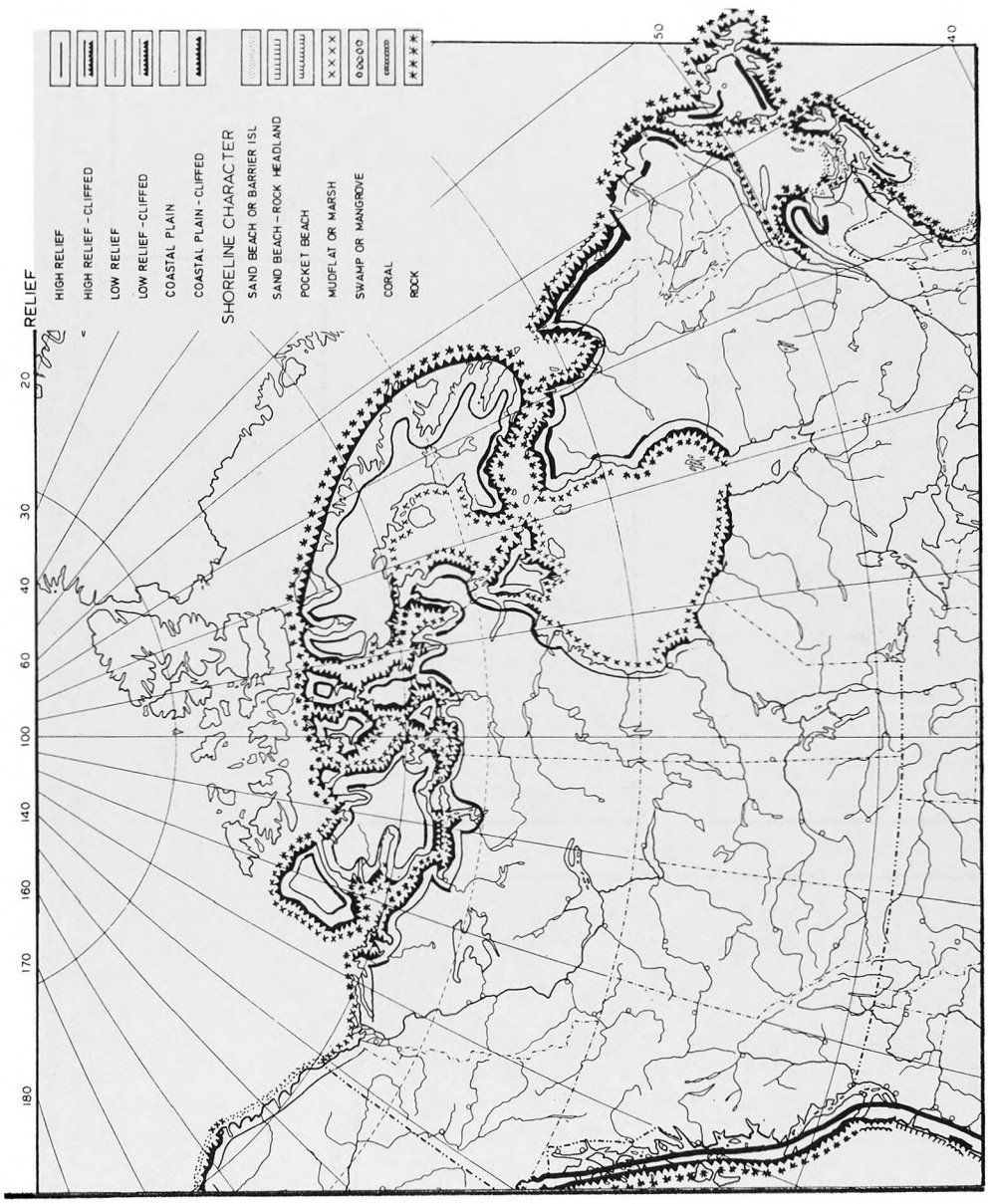


FIG. 9. — Coastal land forms of Canada [7].

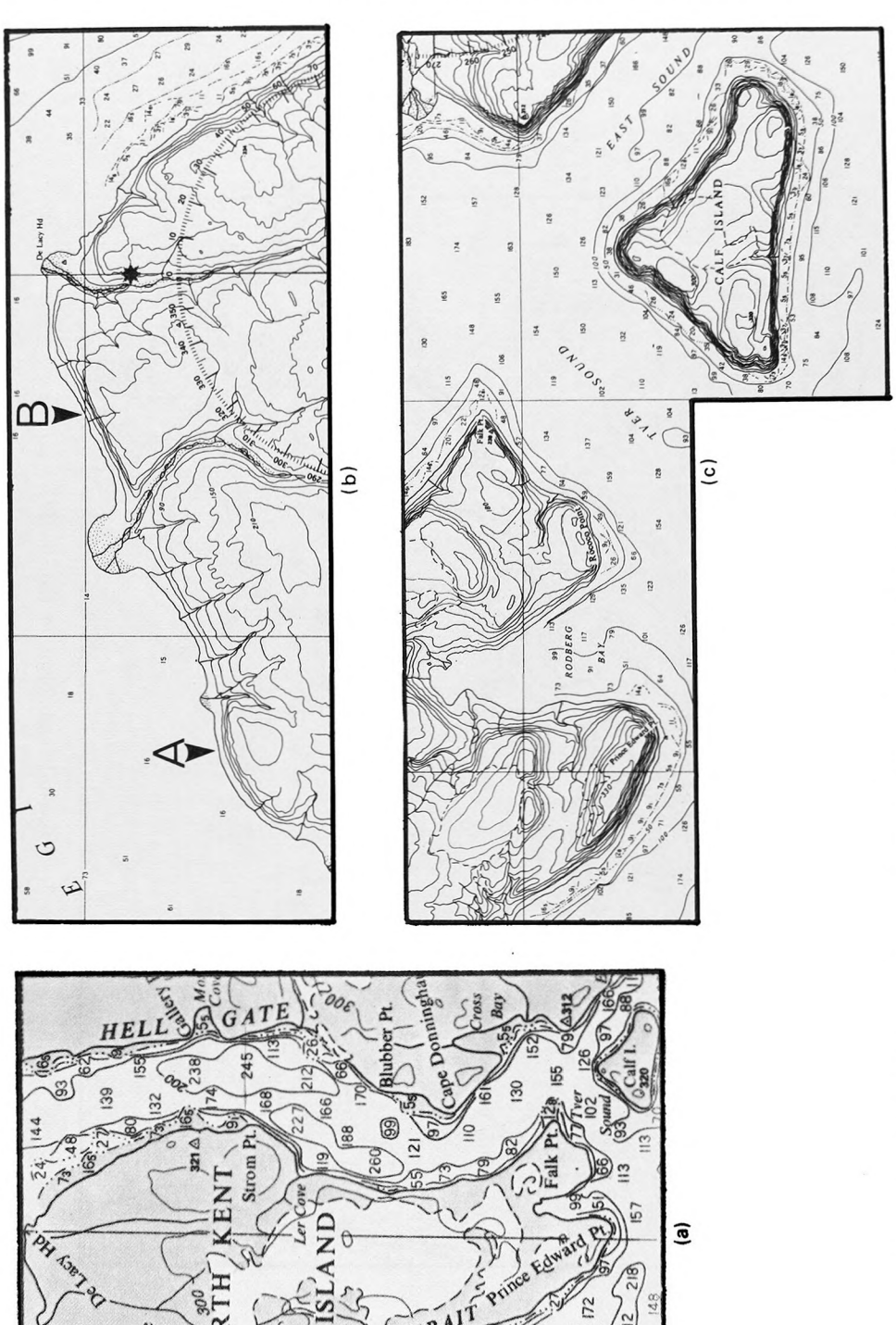


FIG. 10. — a) Canadian Chart 7950, Jones Sound, Norwegian Bay and Queen's Channel, 1974, 1/500 000. b) Canadian Chart 7930, Hell Gate and Cardigan Strait, 1974, 1/75 000. North Coast of North Kent Island. c) South Coast of North Kent Island.

Where it is considered desirable to distinguish between different types of steep coast the above symbol should be used to represent a coast with rocky cliffs and, where the rocky symbol is not appropriate, hachures should be used thus:"

(Para. 312.1).

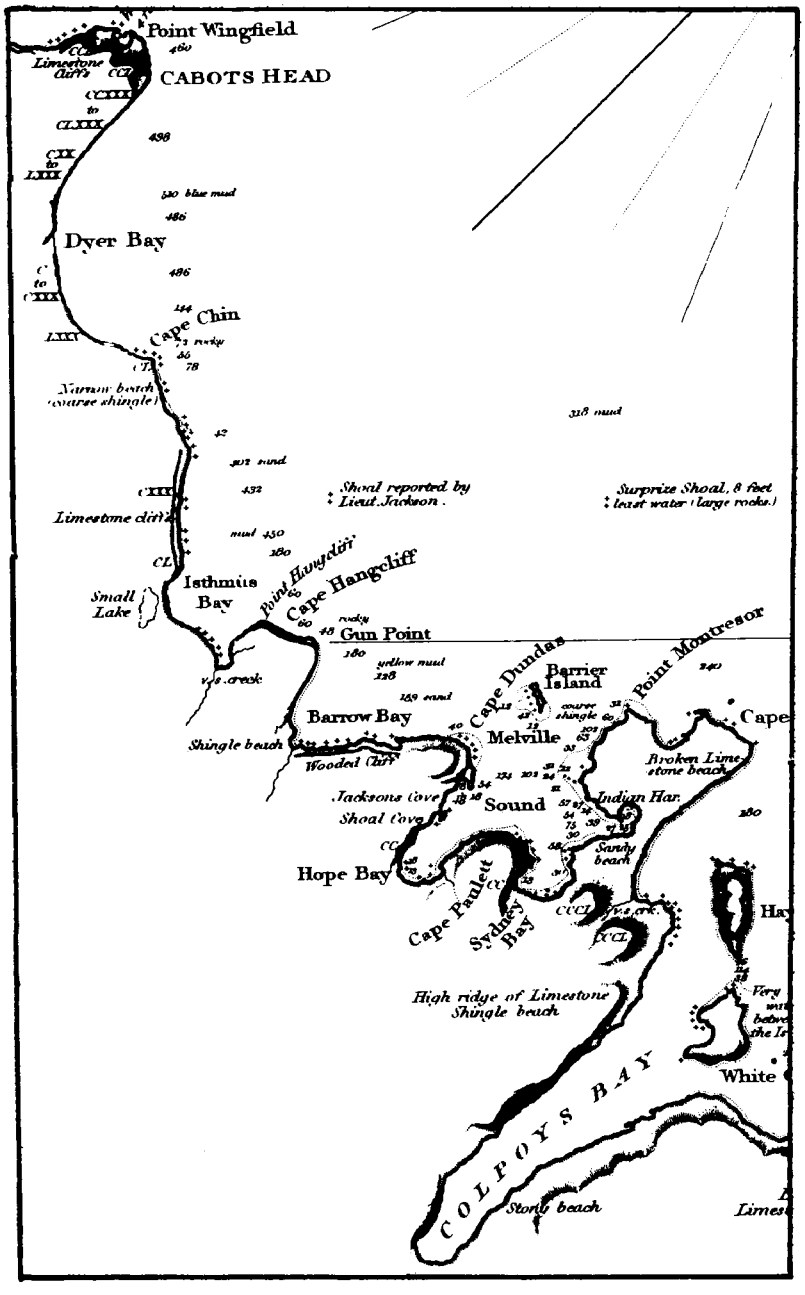


FIG. 11. — Lake Huron, Sheet III, Surveyed by Capt. W.H. Bayfield, 1822. Scale 1/250 000 approx.

Figure 10 (a) shows North Kent Island, between Hell Gate and Cardigan Strait as it appears on 1 : 500 000 Chart 7950. Figure 10 (b) shows the north and 10 (c) the south coast of the island taken from 1 : 75 000 chart 7930. Clearly the larger extract shows the economies that could be achieved on this type of coast, which is so typical, by using the cliff symbol rather than drawing a large number of contours close together. It would also give the mariner a more immediate appreciation of the nature of this inhospitable coast. The 1 : 500 000 chart with its reliance on a 300 m (originally 1 000 ft) contour interval is a complete disaster in this respect. Figure 10 (b) shows a rather more subtle point. At the west end at 'A' there are probably cliffs 120 m high and at 'B' probably cliffs which reach 150 m at the highest point. These would be good radar targets and should certainly appear on the 1 : 500 000 chart, but unfortunately no attempt was made to interpret this information from the larger scale chart.

Figure 11 shows the better appreciation that existed one hundred and fifty years ago when Captain Bayfield surveyed Lake Huron. His practice of using roman numerals to show the height of the cliffs is not recommended for modern usage, in fact I wonder how many Victorian navigators were instantly able to convert "CCXXX to CLXXX" into "230 to 180 feet"?

Glaciers and ice-caps

Ice-caps and glaciers should always be shown on medium and small scale charts, if it is physically possible to see them from seaward, because of their conspicuous appearance. Extensive icefields may also be useful even if they are not directly visible as they lighten the sky above them. Glaciers that reach the shoreline must always be shown to warn the navigator of the risk of calving icebergs.

Conspicuous objects

The hydrographer will continue to show the location and description of conspicuous features on his field sheets, as required by existing Standing Orders. The field sheet will continue to be the primary source for this information for the cartographer. The hydrographer should remember that in surveying the area he had the benefit of numerous sounding marks established for the purpose. These will largely have disappeared when future revisory surveys are carried out and only those which were permanently marked will be shown on the chart. The hydrographer should therefore consider the needs of the hydrographer making revisory surveys and show on his field sheets points which could serve this purpose.

Small craft charts

As one of the primary purposes of small craft charts is to stimulate tourism, as well as to serve the needs of recreational boaters, these charts

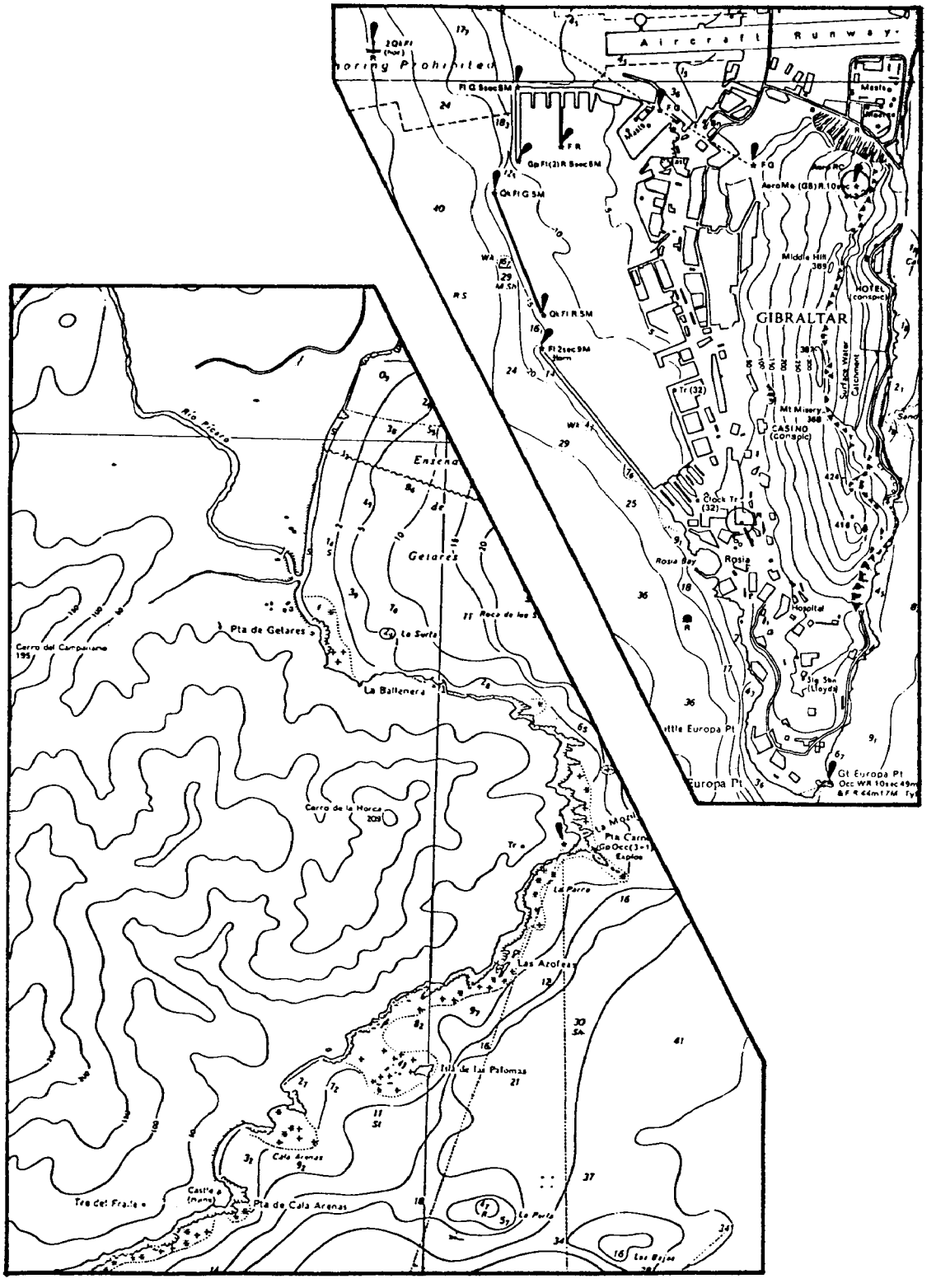


FIG. 12. — Admiralty Chart 1448 Gibraltar Bay, 1968, 1/25 000.

should serve the needs of a combined map and chart. This is necessary as topographical maps are not so readily available and their sheet limits would often require a boater to carry an inordinate number to cover his cruise. The amount of topographic and cultural information that can be eliminated will therefore be less than on a standard chart. The hydrographer should also be alert to other information, such as historic sites, etc., which should be identified.

The task of the cartographer

The main task of the cartographer in the future will be to compile a mosaic of the best available topographic maps which the hydrographer will then annotate in the field. These will usually be the National Topographic Services for medium and small scale charts. For large scale charts, especially major harbours, the cartographer should check to see if the municipality or province has had their own large scale plots prepared.

If a guide to the topographic information to be shown, selected in accordance to the criteria described, is not available the Regional Hydrographer is to be asked to name a hydrographer familiar with the area to assist the cartographer in making his selection. A review of existing and cancelled charts of the area should also be made to see if any exist where the topography was compiled by a hydrographer. These will usually provide a good guide as to what should be shown. For northern and Arctic waters the oblique trimetrogon photographs may also be useful, especially in determining where the cliff symbol should be used.

CONCLUSION

The obvious question is what will a chart prepared using these criteria look like. Figure 12 shows two portions of Admiralty Chart 1448, Gibraltar Bay, published in 1968, amongst the earliest of their new metric format. In its depiction of topography it is in fact close to the NSICC specifications, except that these state:

> "Formlines shall be shown as continuous lines, preferably made bolder in the SE quadrant to represent light coming from the NW." (Section 351.6).

This is going back to a rather similar method used in figure 3.

It will be noted that these charts have a clean uncluttered appearance but all of the essential information needed by the mariner is there.

It has taken over two hundred years for the pendulum to swing from the days of James Cook, when he probably put as much time into surveying topography as he did hydrography, through the days when the Canadian Hydrographer left it to the compiler to copy the topo maps, back to the present where we are again putting the onus back on the hydrographer. I only hope that you will respond to that challenge as well as Cook did.

REFERENCES

[1] PETTIGREW R.F. and CHAMP C.G. : Development of a new Canadian Chart Presentation. 15th Annual Canadian Hydrographic Service Conference, Ottawa, April 1976.

[2] O'SHEA J., CHAMP C.G., LOGAN R.F. and MacPHEE S.B. : The development of chart scheming in the Canadian Hydrographic Service. 15th Annual Canadian Hydrographic Service Conference, Ottawa, April 1976.

[3] BEAGLEHOLE J.C. : The life of Captain James Cook. London. The Hakluyt Society, 1974, p. 33.

[4] *Ibid.*, p. 69.

[5] *Ibid.*, pp. 95-96.

[6] "North Sea International Chart Commission. Specifications – 300 Section – Topography – 3rd Draft, October 1977."

[7] DOLAN R. et al. (1972) : Classification of the coastal environments of the world, Part I, The Americas; Dept. of Environmental Sciences, Univ. of Virginia, Tech. Rept. No. 1, 163 p. Reproduced as figure 15 in E.H. OWENS. Coastal Environments of Canada : the impact and clean-up of oil spills. Economic and Technical Review Report EPS-3-EC-77-13. Fisheries and Environment Canada, Environment Impact Control Directorate, Ottawa, April 1977.