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REPRESENTATIONS ON BATHYMETRIC CHARTS

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PREPARATION OF BATHYMETRIC CHART SERIES IN JAPAN

The preparation of bathymetric charts in Japan started in 1925, when, on the occasion of the Third Pan Pacific Science Congress in Tokyo, Dr. OGURA, a member of the Japanese Hydrographic Department, presented the first bathymetric chart ever compiled in the country. The chart covered the seas adjacent to Japan and was based on sounding data collected up to 1923 by the Hydrographic Department, for the purpose of producing nautical charts. For a long time the nautical chart was accepted as the sole map for the sea.

In 1954 and 1955, a bathymetric survey for the submarine tunnel between Honshū and Hokkaidō was carried out by the Hydrographic Department at the request of Japan National Railways. Since then it has been recognized that the bathymetric chart is an important basis of information for various ocean-related activities.

In 1967, the Hydrographic Department commenced work on a project to produce "Basic Maps of the Sea" (scale 1:200 000) for the continental shelf margin.

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Table 1

	items \ series	1/1mil. bathymetric chart series	Basic Map of the Sea continental shelf series	Basic Map of the Sea coastal series	Bathymetric chart in coastal region	Basic Map of the Sea coastal series
style	issuing organization	Hydrogr. Dept. JMSA	Hydrogr. Dept. JMSA	Hydrogr. Dept. JMSA	Geographical Survey Institute	Hydrogr. Dept. JMSA
	scale	1:1,000,000	1:200,000	1:50,000	1:25,000	1:10,000
	size	96×63cm	63×46cm	96×63cm	91×73cm	96×63cm
	projection	Lambert's conformal conic proj. with 2 standard parallels	Lambert's conformal conic proj. with 2 standard parallels	Lambert's conformal conic proj. with 2 standard parallels	UTM	Lambert's conformal conic proj. with 2 standard parallels
	graduation	every 1'	every 30"	every 10"	every 1'	every 1"
	metric scale	length 200km, both sides	41km, both sides	16km, both sides	2km, one	3.1km, both sides
	graticule	every 1°	every 20'	every 5'	no	every 1'
	colour	9	2	5	3	3
representations of sea	coastal line	single blue line	single black line	nature (i.e.sand beach, mud beach) shown in black	nature (i.e. sand beach, mud beach) shown in blue	nature (i.e. sand beach, mud beach) shown in blue
	tidal zone	not shown	not shown	shown	shown	shown
	interval of isobath	100m	10m where shallower than 200m, 100m where deeper than 200m	1m where shallower than 100m, 5m where 100-200m, 10m where deeper than 200m	1m	1m
	sounding figure	inserted in closed isobath	inserted in closed isobath	inserted in closed isobath	inserted in closed isobath	not inserted
	depression symbol					
	elevation symbol	no	no	no		no
	sunken rock	shown only those offlying	shown as	shown as nautical chart	shown as	shown as nautical chart
	bottom quality	shown	shown	shown	shown	not shown
	layered colouring	9 steps in 3 colours	no	8 steps in 3 colours	no	no
presentations of land	interval of contour	100m, 200m, 300m, 500m and every 500m where heigher than 500m	100m	20m	10m	10m
	town and village	outline	outline	outline	in detail	in detail
	traffic facility	no	no	main ones	in detail	in detail
	drainage	main ones	main ones	main ones	in detail	in detail

Nowadays, official organizations other than the Hydrographic Department are drawing up bathymetric charts for various purposes. As a result, there are several kinds of bathymetric chart series available in Japan, each having slightly different specifications (see Table 1).

Each chart series varies in scale according to its purpose. Similarly, representations are also different. Generally speaking, small scale series are bathymetric in the strict sense. Large scale ones, however, include not only bathymetry, but other marine information related to oceanography, ecology, traffic conditions, resources, maritime or land boundaries, and so on.

A number of bathymetric chart series are now produced in various countries besides Japan. However, specifications are not always uniform. The bathymetric chart is likely to become more and more important as a basis for compilation of maps showing other marine information. It will play the same role as a topographical map does for land maps. From this viewpoint, the bathymetric chart is essential. It is thus important that basic principles and methods for preparing a bathymetric chart should be clearly set out.

In this paper, the authors consider these basic principles and methods for compiling bathymetric charts, and also, as an example of practical bathymetric chart-making, they describe a chart series on scale of 1:1 M recently prepared by the Hydrographic Department of the Maritime Safety Agency, Japan.

BASIC PRINCIPLES FOR DRAWING UP A BATHYMETRIC CHART

a) Overall publication plan

If the bathymetric chart is to become an effective and useful basis for compiling other maritime maps, it is necessary to have an overall publication plan, covering an administrative or topographical region.

For example, a series called "The Basic Map of the Sea" (scale 1:200 000) covers the entire continental margin around Japan. In regard to maps on the scale of 1:50 000, the initial objective is to cover areas which are important in determining the base lines for Japanese territorial waters, and areas where various types of exploitation are taking place. Ultimately, it is intended to cover all the coastal sea around Japan.

b) Survey specifications

To produce a precise bathymetric chart, detailed survey data are required. For this purpose, it becomes necessary to specify the positioning accuracy, sounding accuracy and sounding intervals of the survey. Without going into detail, it will only be noted that the quality of operations in this field improves with the progress of survey techniques.

The actual technique to be used will be determined by the purpose for which the chart/map is to be used. For a nautical chart, the shallow area constituting a hazard to navigation is very precisely sounded, while the deep area is sounded with the broader aim of obtaining an outline of sea bed topography. However, for the purpose of a bathymetric survey, both areas should be surveyed with equal precision. There are two ways of determining the actual survey specifications.

(i) The scale of the chart is first determined. Next, consideration is given as to what type of bathymetric survey should be carried out in order to detect the smallest topographic feature that can be represented on that scale. This method is adopted in preparing a bathymetric chart series which is to form the base map covering an extensive area. Or,

(ii) The initial consideration is given to the extent of topographic features to be included. Then specifications required for the survey of such features are decided. Finally, consideration is given to the chart scale on which the features can be represented. This method is adopted in preparing a bathymetric chart series covering a small area for a specific purpose.

In the case of the Basic Map of the Sea project, the scale of 1:200 000 was initially decided due to budget limitations and the urgency of the task. Then, the interval of sounding lines was determined as 2 miles because the smallest topographic features to be shown on this scale were around 4 km long.

c) Expression of data control

A bathymetric survey comprises lines of sounding conducted along tracks based on the sea bottom profile, and so, apart from a large scale chart covering a limited area where specifically detailed surveys have been conducted, it is common for portions of the seabed between sounding tracks to be left unsounded. These unsounded blanks should be areally expressed by means of depth contours. Accordingly, contouring of the sea bottom should not only be based upon carefully selected existing data, but should also take into account all available geoscientific data. Bottom topography is, after all, concerned with the surface of the mass constituting the sea bottom, and so geoscientific data relating to this mass is very useful in interpreting blank portions of sea bottom topography. However, a bathymetric chart so prepared remains essentially a chart compiled on the basis of present geoscientific interpretation. Therefore, the amount of data the contouring was based upon should be noted. From this an evaluation can be made. The information will show if there is room for other interpretations. It will also be possible to determine areas of scanty data where future surveys are needed. There should be a constant updating of charts with the results of every new survey.

As regards the presentation of data density, there are three main types of annotation : an area on the chart where data is abundant is boxed off; the density of data in other areas is shown by dots and track lines; finally, the information may be incorporated on the chart itself or may be shown on a small index map inserted within the margin of the chart.

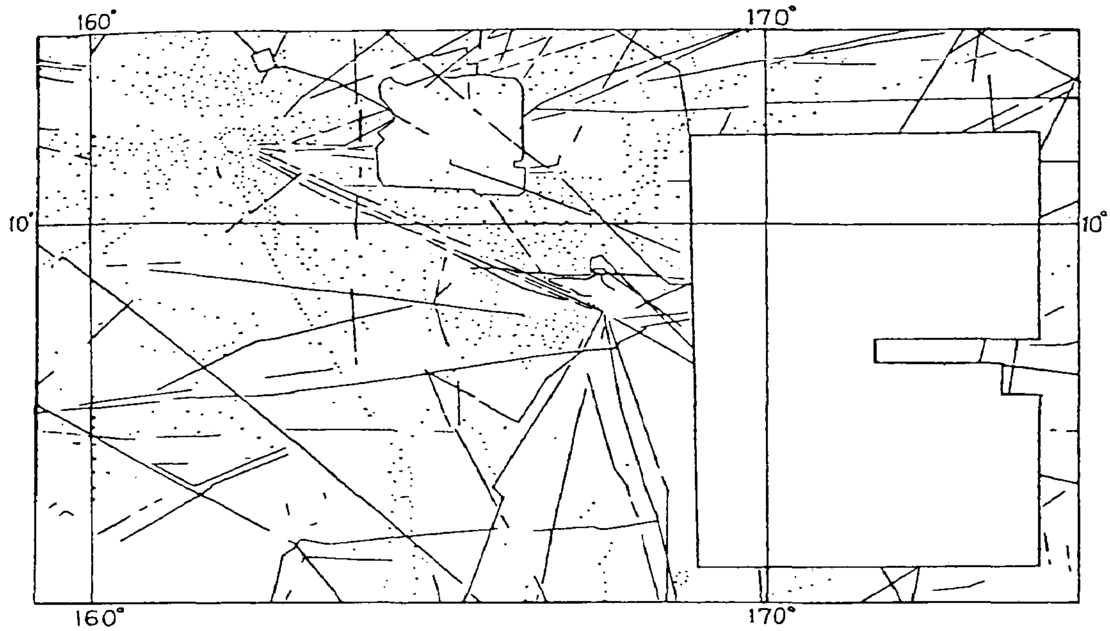

FIG. 1. – Example of representation of data control.

In view of the usefulness of this data quantifier, it seems imperative to include it in the chart. However, it is suggested that the decision on the methods to be adopted should be made after considering the scale and complexity of the chart (fig. 1).

d) Projection

On the Mercator projection, parallels and meridians are shown as straight lines and good continuity with the adjoining sheet can be obtained. In regard to nautical charts, Mercator projection has clear advantages over other projections. As a result, the IHO resolved that "as a general principle, charts shall be produced on the Mercator projection".

However, this projection has more distortion in distance, and consequently in area, as the latitude increases. The resultant effect is that topographic features at different latitudes cannot be compared. It thus becomes preferable to use a projection other than Mercator for smaller scale bathymetric charts. As in the case of land maps, it is difficult to recommend any one projection as the best for a bathymetric chart in general.

Since hydrographic offices issuing nautical charts are also responsible for bathymetric data, they have tended to use the Mercator projection in the collection of this data. As a result, the projection has been adopted for a number of small-scale bathymetric charts.

In Japan the Hydrographic Department of the MSA produces almost all of its bathymetric chart series on Lambert's conformal conic projection. Of course, this does not mean that this projection is necessarily the best for bathymetric charts.

The only conclusion is that one should select the projection which best fits the purpose of the chart.

e) Graticule and graduation

For effective use of a bathymetric chart as a base map one needs to consider ease in plotting planning lines and the results of a survey.

When a projection other than Mercator is used the fact that the parallels and meridians are not straight lines complicates the task. In such a case, it is necessary to draw the graticule with graduations at closer intervals than on a nautical chart.

f) Chart datum

This is of little significance in regard to deep ocean waters, but it requires serious consideration in the charting of shallow water coastal areas, where sounding values may vary greatly depending on the chart datum. For nautical charts, the lowest low water is taken as the chart datum.

However, in regard to bathymetric charts there are two ways of approaching the problem. One originates from the view that, to be considered as a base map, bathymetric data should be based on a single chart datum adopted all over Japan. In this case, mean sea level in a specific area is taken as the datum level, with the advantage that elevations on land and depths at sea are related to a common datum.

The other method is to select an independent chart datum for different areas. In this case, the most common chart datum would probably be the lowest low water, as in the case of nautical charts. The advantage of this datum is that existing data can be used. Various international agreements regarding the sea are based on the low water line, so that the coast lines and low tide elevation lines can be used as they are. The chief disadvantage of this datum is that the bathymetric chart does not strictly correspond to the land map.

It is difficult to judge which of the above is best. However, whatever datum is adopted, it is necessary to clarify within the chart the exact relationship between it and the other reference levels.

g) Unit of depth

Up to now both metre and fathom have been used as sounding units. However, henceforth only the metre unit should be used. Fathom is a specific unit used solely for water depths, but metre is a common unit and in accordance with the c.g.s. system.

h) Depth contours

Depth contours for submarine topography should be lines representing the configuration of the sea bottom. Since the aim of the depth contour on a nautical chart is to identify any hazard to navigation, for reasons of safety the depth contour is drawn through depths slightly greater than the value stated. This idea, however, is not suited to bathymetric charting. A depth contour should pass through positions of the same depth (fig. 2).

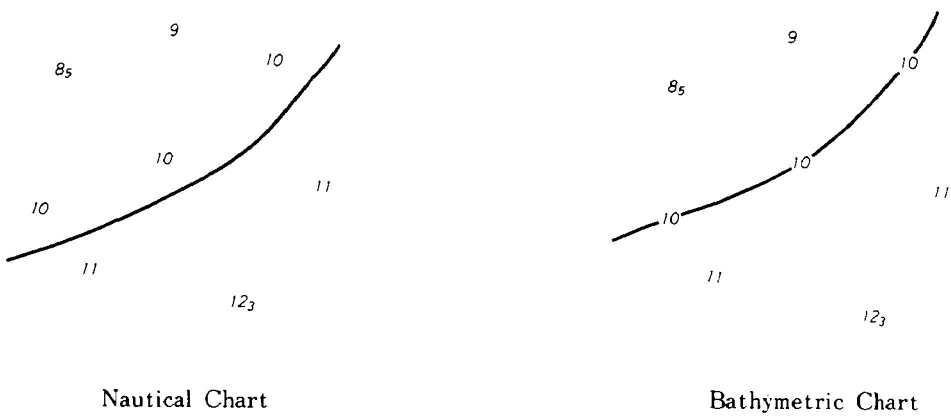

FIG. 2. – Depth contour in nautical chart and bathymetric chart.

It is recognized that depth contour intervals should be equal. However, on bathymetric charts, the intervals are often made finer on shallow and flat continental shelves and coarser on steep continental slopes. Such a method is necessary in representing sea topography, though the resulting contours may cause some confusion to users. Where it is necessary to draw finer depth contour intervals, it is advisable that the contours should be supplemented by partial auxiliary depth contours.

As a principle, equal contour intervals should be based on the decimal division (i.e. every 1 m, 10 m, 100 m, 1 000 m, etc.). In unavoidable cases, it is advisable to use auxiliary depth contours based on bisection (i.e. every 5 m, 50 m, 500 m, etc.).

However, one should avoid using intervals based on quadrisection (i.e. 2.5 m, 25 m, 250 m, etc.) or quinsection (i.e. every 2 m, 20 m, 200 m, etc.), as these will cause serious problems when compiling a smaller scale bathymetric chart covering a wide area (fig. 3).

The fundamental method of portraying the sea bed on a bathymetric chart is by means of depth contours. On many charts various sounding figures are also shown. However, it is meaningless to show soundings except in significant places, e.g. deepest or shallowest point of an area enclosed by a depth contour.

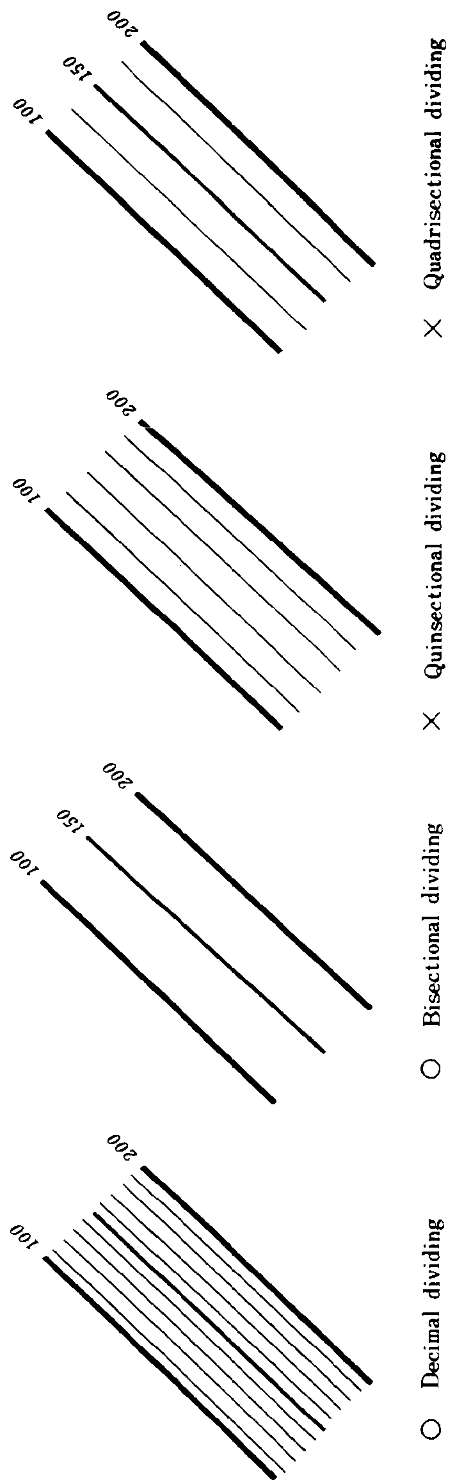

FIG. 3. – Desirable interval of depth contours.

i) Representation of land features

In nautical charts, land features are represented as they appear to the mariner, i.e. only prominent features in view from the sea are shown, with their inland extensions generally omitted. Since it is important to compare land and submarine topography, a bathymetric chart should include inland features represented on the same scale. When a land map on the same scale as the proposed bathymetric chart is available, this can readily be utilized.

Generally speaking, the land features shown on a small scale bathymetric chart are contour lines for major natural features, major drainage systems, and large cities, with their geographical names.

On the other hand, large scale bathymetric charts are base maps for ocean development and environmental problems. Consequently, in addition to natural features, the following should preferably be shown : traffic facilities (road, railway, harbour, etc.), mineral resources (mine, oil and gas fields, etc.), public establishments (hospital, school, office, observatory, power plant, overhead line, national park, natural monument, historic remains, etc.), dangers (oil and gas tanks), plants (atomic power plant, factory, etc.), administrative limits, etc.

j) Symbols and abbreviations

Few symbols and abbreviations are used exclusively on bathymetric charts. Symbols and abbreviations used in land maps and nautical charts are adopted to represent topography and hydrographic information. However, it is possible that in the near future, the necessity of representing the many above-mentioned features will bring about the introduction of various symbols and abbreviations for large scale bathymetric charts. It is also important to check and standardize the symbols and abbreviations in use at present.

k) Nomenclatures and geographical names of sea bottom features

A variety of nomenclatures and geographical names for sea bottom features have been adopted by various countries and organizations, especially in small-scale bathymetric charts. Attempts to standardize nomenclature have been carried out a number of times. At present the U.N., in coordination with the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features, is attempting to standardize geographical names of submarine features. Once the task has been completed, it will be necessary to prepare a glossary of terms of the nomenclature in various languages.

l) Up-dating of the bathymetric chart

The vastness of the ocean and the efforts required to chart it entail considerable cost. Hence, a smaller scale bathymetric chart is generally a collection of surveys carried out over a long span of time by the ocean research institutions of various countries. Even in the case of a large scale bathymetric chart, collection of data and information is very important. Also, as survey techniques and equipment improve, more accurate data to replace the old becomes available.

In order that bathymetric charts can be updated as a result of available new data, it is necessary to establish a bathymetric data bank in digital form. There is also a need to standardize the codes for data collection on an international basis. At present, studies are being made by the International Hydrographic Bureau to codify the quality of bathymetric data according to 4 criteria – position accuracy, sounding accuracy, fidelity of scaling soundings to reproduce the seabed, and data processing.

BATHYMETRIC CHART "HOKKAIDO" IN 1:1 M SERIES

The purpose of this new 1:1 M bathymetric chart is to compress into a smaller scale the "Basic Map of the Sea" series of 1:200 000.

It is intended to extend its coverage over the continental margin from the trenches on the oceanic sides to the floor of the back arc basin. The overall publication plan is shown in figure 4. The 1:1 M series sheet was compiled by a reduction of the 1:200 000 bathymetric charts and supplemented by GEBCO 1:1 M plotting sheets. Data control was shown within the chart by limits of areas precisely sounded around continental shelves and by dots and track lines in other places. A small explanatory index chart was inserted within the margin.

The projection adopted is Lambert's conformal conic projection which is the same projection as used in other bathymetric chart series issued by the Hydrographic Department. The standard parallels were 30° N and 43° N. Graduation of graticules is at every 1 minute along the marginal and intermediate parallels and meridians. Intermediate graticules are drawn at every 1 degree interval. Linear scales are shown along both sides of marginal meridians. Interval of depth contours is every 100 m and auxiliary contours where necessary are drawn at 50 m intervals. As the sheet is a small scale one, the following land features are depicted : coast line, contour lines (100 m, 200 m, 300 m and every 500 m above this) based on a 1:1 M scale land map of the IMW (International Map of the World), spot heights at elevations, major cities, rivers, lakes and administrative boundaries.

In addition to depth contours the following sea bottom features are shown – spot depths at highs or depressions, depression symbols, isolated low tide elevations and sunken rocks. However, reported depths, bottom character, wrecks and maritime limits are not shown.

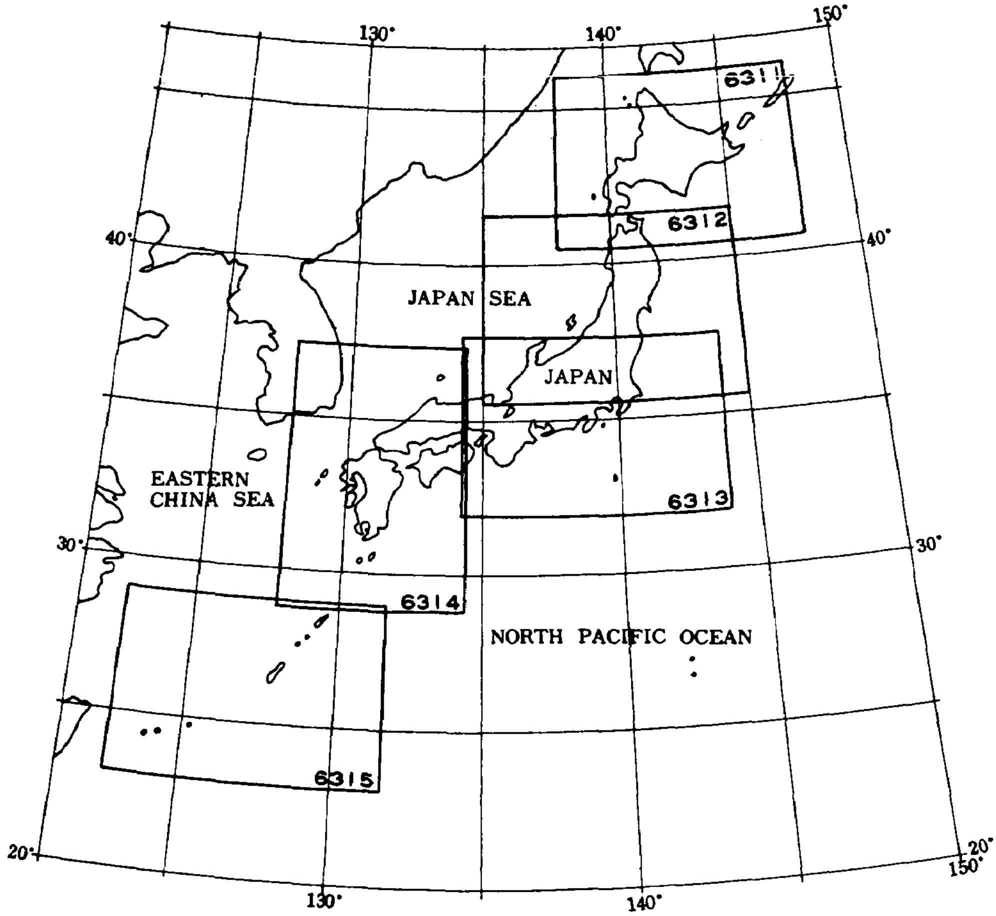

FIG. 4. – Publication plan of 1/1 M bathymetric chart series.

Geographical names are selected according to the following criteria :
- administrative (province, prefectures and major cities);
- natural features (major mountains, rivers, lakes, islands and capes);
- sea area (oceans, seas, straits and large bays).

Names of submarine topography are inserted as precisely as possible on this scale.

The use of colours in bathymetric charts was not discussed in the preceding chapter. Since the use of colour heightens the representational character of the chart, a multi-colour chart is clearly desirable. However, other considerations must be made. For example, cost and time considerations may limit the amount of colour used. In the case of this sheet, land elevation was represented by layered colouring at six steps in three colours : 0-200 m, 200-500 m, 500-1 000 m, 1 000-2 000 m, 2 000-3 000 m, and over 3 000 m.

Sea bottom topography was expressed by nine layers in three colours : 0-200 m, 200-1 000 m and every 1 000 m below this.

Many of the ideas included in this paper have been developed from suggestions contained in "How a desirable bathymetric chart should be", a paper by B. IMAYOSHI, submitted to the 8th UN Regional Cartographic Conference for Asia and the Far East.

The authors wish to express their thanks to the members of the Japan Cartographers' Association Commission on Oceanic Cartography for their continuous encouragement in the preparation of this paper.

LARGE TANKERS :
SAFETY AND IMPACT ON MARINE ENVIRONMENT

In the years to come the traditional right of vessels to navigate the high seas without let or hindrance will be increasingly challenged and the question of control of shipping will become a contentious subject. This argument is already being developed (although not always very rationally) with the oil pollution threat in mind, and now that liquefied gases and noxious cargoes are attracting much more attention, pressure to achieve greater control is bound to increase. At the risk of adding fuel to the flames, I feel there is need to utilize the technology already available to us to regulate the passage of ships, particularly in congested waters, in such a way that risk is minimized, and in a more positive way than is done at present. How this should best be done needs careful study, but a traffic regime such as we have in the Channel, for example, which allows ships of all types, with all sorts of cargoes, with varying navigational equipment, and manned by crews of vastly different qualifications, to sort out their destinies unaided is unlikely to be optimum. Added to which fishermen expect to be free to fish in the traffic separation schemes and yachtsmen wish to be able to pursue their recreation without hindrance and to continue to exercise their right to have steam give way to sail.

The professional mariner currently gives cautious approval to shore-based information services but reacts strongly to the word 'control' and even more strongly to suggestions that there might be something to learn from the field of aviation. With the wide range of products now being carried by sea, which have a capability of damaging the marine environment should they be spilled, the public has a right to be assured that all reasonable precautions are being taken. It is in the shipping industry's own interest to take a lead in developing more appropriate traffic systems, and if it does not it may find what is imposed on it not to its liking. These issues are not one-sided, however, and the public on its part must recognize that preservation of the environment can be costly and that the common good is not necessarily good for every individual. An example of this is the need to salvage tankers in trouble and the reluctance which has recently developed to allow them access to ports of refuge because of the threat of coastal pollution this may involve. This is putting seamen's lives at risk, as well as the ships and their cargoes, and this may increase pollution rather than diminish it. High Court injunctions are all very well, but we should remember that it is our collective appetite for energy which is responsible for tankers navigating off our shores in such large numbers. Accidents cannot be avoided completely and, when they do occur, those having responsibility to deal with their consequences have a difficult enough job without impediments being put in their way.

Extract from : "Large tankers : Their safety and their impact on the marine environment". The Thomas Gray Memorial Lecture by Ralph MAYBOURN. Published in *The Royal Society for the encouragement of Arts, Manufactures and Commerce Journal*, July 1980, No. 5288, Vol. CXXVIII, London.