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OBSERVATIONS ON A SEAMAP

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ABSTRACT

An analysis of a small-scale bathymetric map, SEAMAP No. 13242-12B, published by the U.S. National Ocean Survey, is presented together with information on its genesis and format and general comments on the future of maps depicting deep ocean bathymetry.

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Most of the earth's surface was mapped in the gross sense in the past 25 years. This refers, of course, to the sea floor, and in particular to that portion lying deeper than several hundred metres. The waters shoaler than this average depth, overlying the continental shelf in many areas – not all – have been *charted* to considerable accuracy. It may be tempting, as a result, to view our contemporary knowledge of the sea floor and its shape as extensive, but this is true only when compared to an earlier time. All we can say is that an acceleration in accumulating that knowledge has occurred. To understand a spatial variable in all its ramifications, one must first be able to describe it analytically. By such standards the sea floor still lies relatively unmapped, and, therefore, relatively unknown.

Bathymetric maps as marine graphics may be distinguished from their nautical or hydrographic chart counterparts by a number of factors, and it is sufficient to note that the depiction of relief is one characteristic that can be common to both. Hydrography is a somewhat ambiguous form, for to an oceanographer the hydrography of an area actually consists traditionally of water column and other physical oceanographic properties, while to the hydrographic engineer it

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denotes sea floor shape. Recent applications of hydrographic data associated with offshore activities have broadened whatever definitions were once applicable, but as a rule the terms nautical and/or hydrographic are still retained, referring to the chart with some navigational end in mind. Relief on the map may be said to be its *raison d'être*; on the chart, relief can be of no little importance, but it is a selective characteristic that can be displayed to varying degrees of intensity, and, thus, accuracy. Mapped, as opposed to charted, relief can be of interest for many diverse reasons, whereas on the chart used for navigation it is mostly something one wants to avoid.

Requirements for greater quantitative information on the configuration of the sea floor have increased dramatically – consider such events as the search for offshore energy, marine mining, and earthquake prediction and other research – with programs of bathymetric mapping established by many nations in response to these needs. Maps at 1:250 000 have taken on unofficial status as the standard for continental shelf mapping; some maps are produced at quite large scale, such as in the United States, where 1:24 000 production is beginning, and 1:100 000 scale and other series are also prepared. World coverage is achieved by the GEBCO series of maps, now recognized for the valuable product it is. Finally, considerable bathymetric data are obtained from a variety of geophysical investigations and published as maps to accompany papers in the scientific literature. These are invariably at a small, often undefined, scale.

By far the majority of this work necessitates compilation from one of two sources: data obtained through larger-scale charting, and those assembled from random soundings in deeper areas. This is not to diminish the worth of either – certainly not the charting source, and in many instances not that of random data – yet the systematic collection of data at sea for the expressed purpose of producing given bathymetric maps has been rare. It can be seen that this defines a limitation on the depth range in which maps can be prepared based on purposeful accumulation of data to cartographic standards. This can have importance because marine graphics issued by government agencies are often looked at by the general public as worthy of unquestioned acceptance, a situation always as embarrassing as it is flattering.

The term SEAMAP is an acronym for Scientific Exploration and Mapping, and the series is worth examining because it represents one of the first attempts to map the properties of deep ocean areas on a systematic basis. In genesis and form, it was a product unique to its time. The particular graphic selected for closer scrutiny is SEAMAP No. 13242-12B, of an area in the north eastern Pacific off Oregon and Washington (figure 1), at 1:1 000 000 with variable 20 and 100-metre contour interval, published by the U.S. National Ocean Survey in 1973.

The SEAMAP program had its origin in the early 1960's and was carried out under the aegis of the predecessor agency to the National Ocean Survey, the venerable and once-preeminent Coast and Geodetic Survey. This was a time of worldwide expansion in the marine sciences, the climate being conducive to many new thrusts for gaining oceanographic knowledge. SEAMAP was to be a program of ocean wide surveys, a descriptive characterization of the deep oceans stressing underway measurements of bathymetry, geomagnetics, gravity, and seismicity. Careful groundwork was prepared by notable American scientists, and

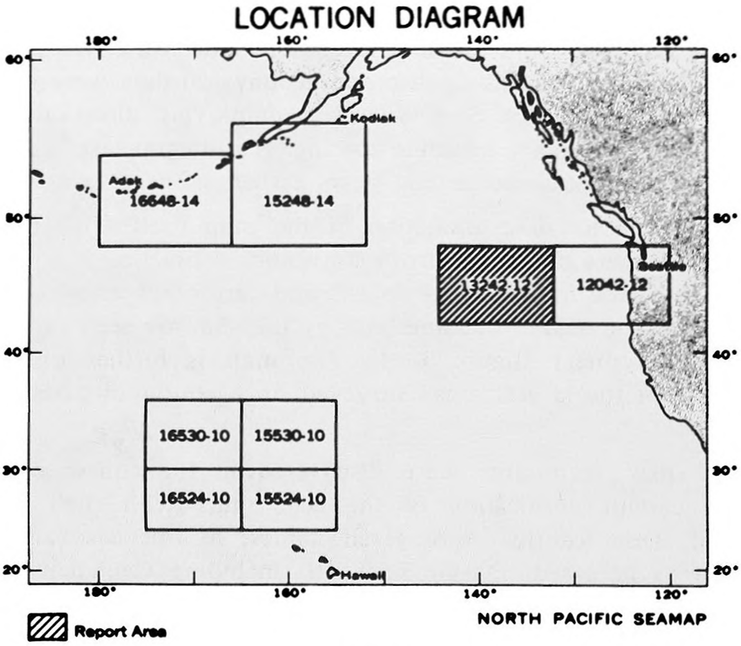

FIG. 1

arguments assembled and put forth on the value of pursuing this means for learning more about basic oceanic processes. The advantage of intensive descriptive endeavors had in fact been demonstrated in the previous decade by discovery of the Mendocino, Pioneer, and Murray fracture zones and their magnetic lineations. However, the conceptual approach envisioned for SEAMAP was never to be fully realized. This was due to the low priority accorded it, made worse by a controversy then raging over the proportion of Federal funds to be applied to programs of research or to surveys. Events went so far as to separate research and surveys in the formal planning and budgetary schemes then in use, and even ships were constructed, dedicated to one or another of these arbitrary classifications.

It is, perhaps, of some consolation to recognize that proponents of the SEAMAP concept were ahead of their time, prophets who foretold contemporary concerns in the oceans with relative precision. As an immediate consequence, however, SEAMAP investigations were conducted sporadically, beginning in an irregular region from Hawaii to the Aleutians, but never completed. The large amount of data amassed by even this limited effort was not fully processed until years later, and the latter part of the decade found interest in the program waning.

After some two or three years had elapsed, our particular SEAMAP was conceived in 1970 as part of the International Decade of Ocean Exploration, a program administered in the United States by the National Science Foundation. Work was to include preparation of coordinated map sets of ocean bathymetry, geomagnetics, and gravity (the magnetic map in the set in which No. 13242-12B is found is No. 13242-12M, the gravity map No. 13242-12G). Additional end products in the form of seismic plots, profiles, computerized data lists, and numbers of special analyses were also to result. Geodetic control for the operation was to be LORAN-C and satellite navigation, and work was planned in the area shown in figure 1. All bathymetric and geophysical data were to be obtained simultaneously by the NOAA Ship *Surveyor*, employing directional echo sounders, at 18 000-metre primary trackline spacing. An integral task was to complete processing of the data obtained several years earlier in the area north of Hawaii.

We now come to an examination of the map itself. This reveals certain characteristics that were departures from conventional practice, e.g., in the margin is found citation of the individual geologists and cartographers who compiled the data (figure 2) and the actual tracklines run by the ship are seen superimposed on the published bathymetry (figures 3, 4). The map is further distinguished by representing one of the largest areas surveyed on a continuous basis by a single ship.

Some 37 new seamounts were discovered in the course of the survey, confirmed by careful verification of the echograms with their precise plots. Twenty-five of these features were given names, in this case after prominent living, as well as deceased, marine scientists, including Canadian and Japanese scientists who participated in phases of the operation : Chase, Dehlinger, Gordon, Iwabuchi, Kagami, McNab, McKernan, McManus, Menard, Nichols, Nierenberg, Raff, Raitt, Revelle, Richards, Schaffer, Shalowitz, Shor, Spilhaus, Srivastava, Stanley, Terry, and Vaquier. The names Emilia and Iisuka were given to seamounts on the SEAMAP to the east (12042-12B).

The seamount names were applied through a procedure requiring the approval of a committee of the U.S. Board on Geographic Names. Not all the seamounts on the map were named; this was limited to those features which could be certified unequivocally as newly discovered. It was found that many of them

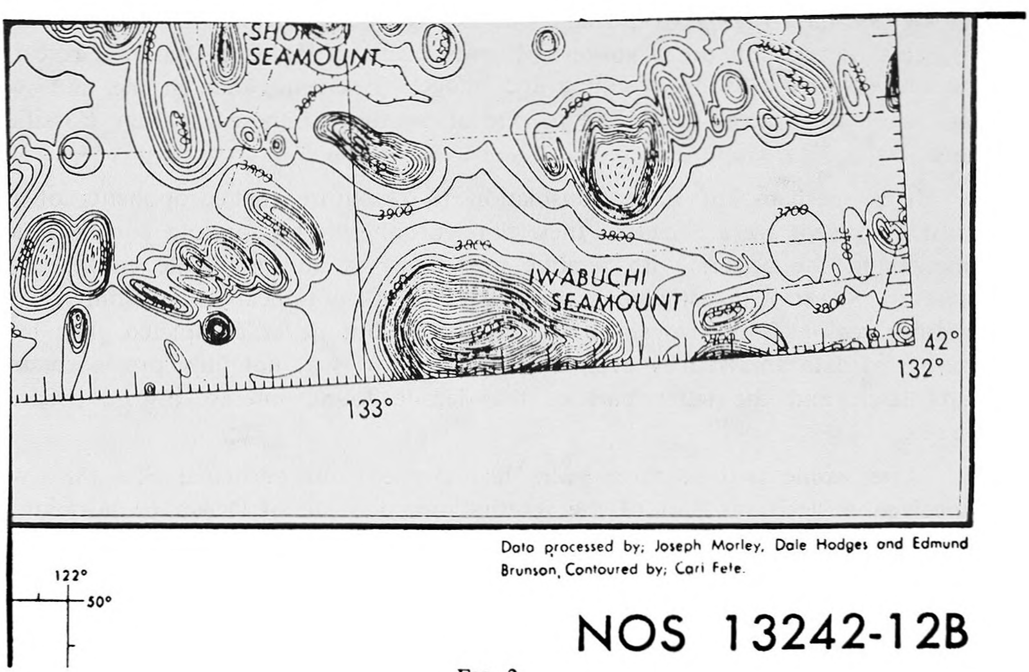

FIG. 2

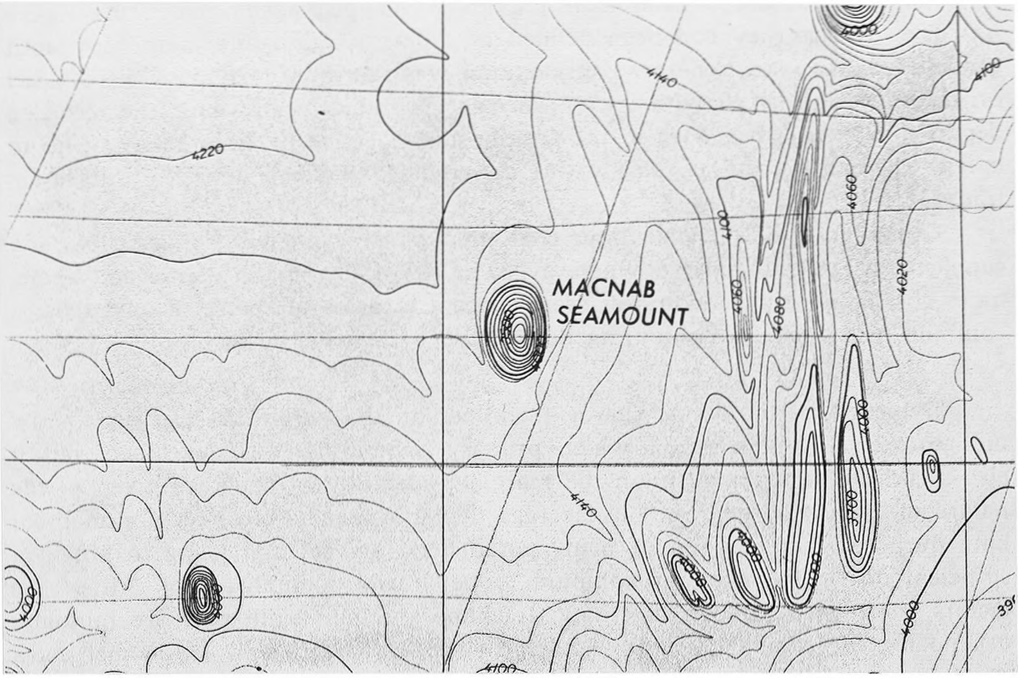
MACNAB
SEAMOUNT
4220
4140
4100
4060
4020
4080
4160
3700
4000

FIG. 3

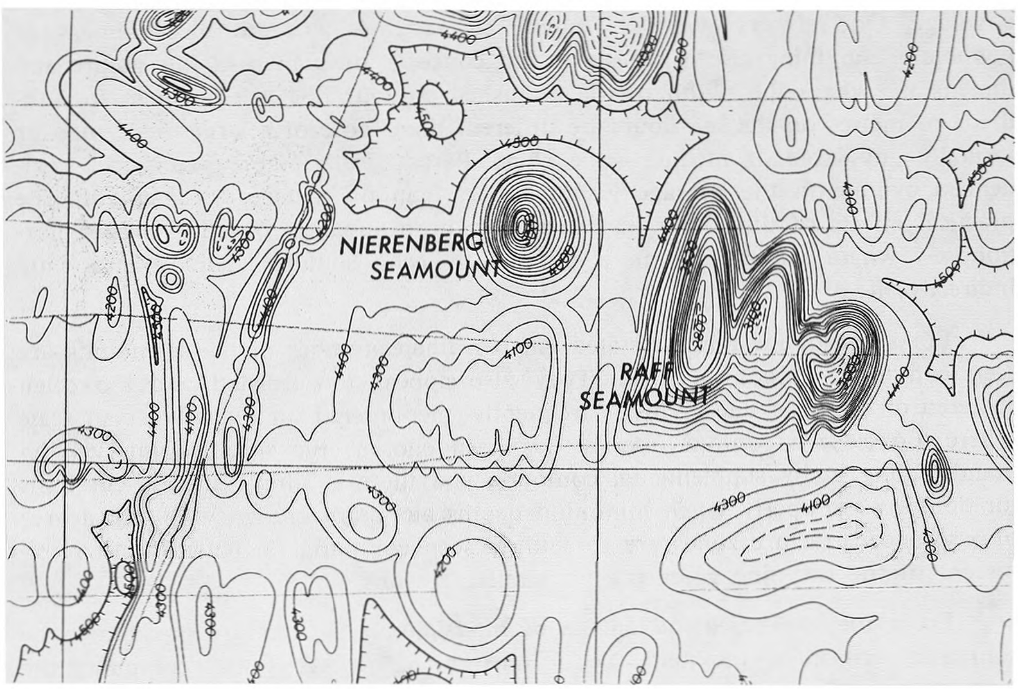
NIERENBERG
SEAMOUNT
RAFF
SEAMOUNT
4400
4300
4500
4200
4100

FIG. 4.

now appeared displaced from their previously mapped position, i.e., they were not new; rather, they had been defined in a new position due to the advanced geodetic control used. Another consideration was that the older maps were based on measurements taken with wide-beam echo sounding transducers, the recorded depths of which possibly led to the position displacement of an anomaly of up to a few kilometres from its position as determined by using a highly directional transducer.

Compilation of the data onto contoured plots was aided by using existing supplemental source material where available. Typically, highly dense and sometimes conflicting information was seen adjacent to areas of sparse, if any, data, a common occurrence in contouring deep ocean bathymetry at any but very small scale.

Depiction of the actual survey tracklines on the published map does show the geometric framework on which primary contouring was developed, but it also serves to bring to attention the marginal adequacy of coverage given to the nature of the topography and its average depth. Adequate coverage for mapmaking purposes is a function of many parameters, the net aim being to obtain a sufficient density of data for contours to be drawn unambiguously. All of the factors, such as tranducer directivity, trackline spacing, depth, etc., are mutually dependant; for example, conditions improve when coverage is maintained as a constant in the equation and scale is reduced, and worsen when relief lies deep as well as being complex and as the scale increases.

Although single-transducer directional sounding (2-5 degrees) has important application, it can reflect nothing more than a modified leadline approach when used at wide trackline spacing in complex topography that lies deep. At 1:1 000 000 the accuracy of given data points can be considered subordinate to coverage. One always wants to obtain as accurate a depth measurement as possible – anything else is heresy – but concerns on a map of this nature and dimension, where the width of the published contour line is equivalent to hundreds of metres on the sea floor, are different than those of a larger-scale map or virtually any large or medium-scale chart. Paradoxically, more precision is evidenced overall on the average inshore chart than on a deep sea map, but the practical effects of directivity on charts are more apparent on their deeper portions – where safe navigation is affected by echo sounder characteristics only indirectly, if at all.

For some of the reasons stated, an inordinate number of the seamounts are seen contoured in conical form. They also appear too isolated and too often centered on the tracklines. This is frequently encountered on maps at small scale where too close a contour interval has been chosen; the specified interval demands filling in by supplemental contours, and there is simply insufficient basis for doing this properly when minimum depths alone are known with any degree of assurance. Fracture zones are sometimes seen contoured in patterns too reminiscent of the trackline geometry for similar reasons.

From the convenient advantage of hindsight, it is therefore possible to be somewhat critical of the map. Yet it must be remembered that compiling the bathymetric map was but one objective, with the intensity of survey coverage among several compromises reached in the interest of achieving technical balance within available time and resources. (Today, the cost of fuel in itself would be a limiting variable). The critical nature of these comments notwithstanding, the map and its accompanying data reflect excellent interpretation, given the difficulties cited, contributing valuable insight to the geophysical characteristics of this part of the Pacific Ocean.

No unusual foresight is necessary to predict that multiple-beam echo sounding should revive interest in the systematic mapping of the deep ocean. This idea of obtaining measurements at once directional yet of large areas on the sea floor was first conceived for meeting naval requirements. Indeed, it is probable that the expense of developing and testing multiple-beam equipment could have been borne initially only by a defense establishment. This being true, it is still to the credit of naval scientists and administrators that there was immediate grasp of the new concept and what it could mean for marine mapping. The U.S. Navy had, in fact, led earlier in the development of directivity from stabilized transducers, also pioneering in the simultaneous operation of directional and standard transducers.

The basis of multiple-beam echo sounding rests on employment of separate arrays of acoustic projectors and hydrophones. One system in use today (by France and the United States) consists of an array of 20 projectors mounted in line, and a receiving array of 40 hydrophones. A path on the sea floor is sounded whose width can be 50-70 percent of the depth. The ability to have computer-produced contoured maps generated in real time is one of its many innovative features, and there is a shallow-water system for charting purposes. When the author suggested the term "swath sounding" to describe operation of a similar system of multiple-beam units some years ago, he ventured it had the potential to be as much an advance over conventional sounding as this latter did over the leadline. It remains to be seen whether this prediction comes to pass, but one thing seems certain : sea floor maps prepared utilizing multiple-beam concepts always make existing maps at similar scale obsolete. Years hence it may be possible to perceive a watershed in the annals of echo sounding associated with the introduction of multiple-beam systems, just as we do for the echo sounder itself in the period following World War I.

Requirements for bathymetric maps, of which SEAMAP and GEBCO are prime examples, have historically been difficult to convey in terms readily understood by program administrators and budget analysts. It was and is necessary to compete for funds in an arena stipulating urgent and identifiable needs for specific user constituencies. Such rules cannot really be faulted, except that lower priorities can never be taken to mean non-essentiality. In the last analysis, such maps are tangible expressions of our relationship to the marine environment of which we are all part and of our resolve to manage it wisely.

This discussion reflects the author's personal views.