~~Trauter~~ DJ
Newell BN.
~~Jolts~~ HF
~~Hansen~~ BH
~~Rochford~~ DR

UNIVERSITY OF CALIFORNIA

SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

2 June 1964

Dr. G. F. Humphrey
c/o Dr. K. N. Fedorov
UNESCO Office of Oceanography
Place de Fontenoy
Paris 7, France

Dear George:

Herewith the report of the SCOR Working Group on Atlases, whose membership is Dr. V. Hansen, Prof. S. Motoda, Prof. C. Ramage, Prof. P. Bezrukov and myself. We hope this will suffice to show that atlases can and should be made of the Indian Ocean.

My very best wishes for completion of the atlases at the earliest time consonant with the proper study that the materials deserve.

Yours sincerely,

Jo

Joseph L. Reid, Jr.
Chairman, SCOR Working Group on Atlases

cc: P. L. Bezrukov
V. Hansen
S. Motoda
C. Ramage

rp

P.S. I am sending with this only one carbon copy. The original and other copies will be brought to you by Warren Wooster. I am sending copies to the W.G. also, but if they attend the SCOR meeting they will not receive them until their return. Would you please provide those W.G. members who attend with one of the copies Wooster is bringing?

REPORT TO SCOR BY THE WORKING GROUP ON ATLASES

1. The scientific requirements for, and scientific principles of, preparation of atlases of marine scientific data.

The first purpose of an atlas is to display in a clear and accurate manner the various properties of its subject, so that investigators with various interests may turn to it to gather information pertinent to their particular problems.

For marine atlases there are other purposes. Land atlases are highly developed and except for color and scale a new one may be so like earlier ones that only the specialist examines it for new features. Marine atlases are very few and most of them are either of small area, small scope or sparse data. A detailed atlas of the entire Pacific, or of the Indian, Arctic or Antarctic oceans might show unexpected features or new and different aspects of old ones. Making such an atlas is not a routine assembly or a minor refinement of earlier work: it is an exploration.

Another purpose that a marine atlas might serve is to bring together maps or vertical sections of various properties that have not been viewed together before: physical, chemical, biological and geological features may suggest or show unanticipated similarities, contrasts, and relations.

For the first of these purposes to be served data of high quality and adequate distribution in space and time are required. It may sometimes be worthwhile, however, for the other purposes, to examine and display even rather sparse data, or data of second-rate quality. After all, if the data were complete and trustworthy it would be better to leave the function of atlas-making to modern computing-machines: the function of a scientist is to try to perceive any possible order in the midst of what might seem chaos to such a machine.

There are perhaps no marine atlases in which the data were adequate and did not require some interpretation. The Meteor expedition's east-west track-lines made contouring of properties on horizontal surfaces uncertain: in particular the equatorial data left much to be desired. Even surface maps of temperature and salinity become questionable in high latitudes in winter, and recent data from the Pacific suggest that Schott's surface salinity map needs severe revision in the equatorial area.

It seems reasonable to assume that for some time to come atlases of many oceanic properties will continue to be based on scanty and perhaps in part on doubtful data. The decision as to when a map is or will become complete enough to justify discussion and publication may sometimes be a hard one. The map itself should be made by or under the supervision of an interested scientist only: it is not likely that a mere clerical treatment, however technically correct, will be able to separate good and bad data.

Under these circumstances the determination of the practical scientific requirements for and scientific principles of preparation of a marine map should properly be left to the scientist interested in making it. Rigid requirements for high-density data of first-rate quality might exclude some extremely useful and fundamental presentations. A lofty set of principles, enforced in a strict manner, might discourage some perhaps illuminating interpretations. In any case the varying quantity and quality of materials would require a different set of standards for each oceanic property (and perhaps for each different level and each ocean).

As a consequence it is best not to write down specific criteria, and instead to recommend that each map prepared should be examined on its own merits. In the case of an atlas of maps prepared by several people an editor and review board must make some choice. It is much better to appoint competent people and trust to their good judgement.

2. What atlases will be possible as a result of the Indian Ocean Expedition.

a. Meteorological Atlas

An outline for IIOE meteorological atlases has already been prepared by Dr. Ramage and distributed for comment. It is reproduced here in its original form.

OUTLINE FOR IIOE METEOROLOGICAL ATLASES

1. BACKGROUND

One of the most significant and potentially useful products of the IIOE will be a series of Atlases presenting Expedition data in forms suitable for research use.

It is now possible to visualize two Meteorological Atlases, one describing the upper air, specifically for use by meteorologists, the other embodying near-surface data and designed with the needs of physical oceanographers, meteorologists, biologists and fisheries scientists in mind.

As SCOR-appointed editor for IIOE Meteorological Atlases, I have already received suggestions from several interested scientists; however, many more should be consulted and to this end I am distributing this appendix as widely as possible. Since a meeting of the SCOR working group on Atlases will soon take place I should greatly appreciate receiving comments, criticisms and suggestions by the end of March 1964, so that they might be incorporated into a plan to be considered at the first meeting of the SCOR working group on Atlases.

It would also be useful to know how many copies of the atlases you would like to obtain.

So that you may better be able to evaluate my proposal I attach a chart of the scale and projection suggested, showing the areas for the upper air and surface charts and also showing the number of usable observations made in each 5-degree square during the typical month of June 1963, by ships (upright figures) and at small island stations (sloping figures).

2. SCOPE

2.1 Data - from all available IIOE and other sources, for the two calendar years 1963 and 1964.

2.2 Time Interval and Area Unit - calendar month and 5-degree latitude-longitude square (except where otherwise stated). Within each 5-degree square the average latitude and longitude positions of all the observations will be determined and the data plotted at that point and not at the centre of the square.

2.3 Area

2.3.1. For upper air atlas - 45°N to 50°S; 20°E to 155°E.

2.3.2. For surface atlas - the ocean area enclosed between the east coast of Africa, southern Asia, southern Indonesia, West Australia, 20°E and 145°E, and 50°S. There are 250 five-degree squares in this area.

2.4 Projection - Mercator.

2.5 Scale - 1:40 million (same as the U.S. Navy Marine Climatic Atlases of the World).

2.6 Format - photo lithographed from automatically printed-out, hand-analysed data in loose-leaf binding to facilitate changes and intercomparisons.

2.7 Units - metric, apart from knots for wind speeds.

3. CONTENT

3.1 Upper Air Atlas -

3.1.1. Plotted data - monthly mean resultant winds and steadiness at all upper wind sounding stations and monthly mean pressure heights, temperatures and dew points at all radiosonde stations plotted on charts for the standard pressure levels of 850, 700, 500, 300, 200 mb.*

3.1.2. Analysis - streamlines of the resultant wind directions.

3.1.3. Auxiliary charts - monthly mean atmospheric cross-sections for the meridians of 30°E, 73°E and 140°E**, from 45°N to 50°S on the same distance scale as the standard charts and on a convenient vertical scale.

3.1.3.1. Plotted data - monthly mean N-S and E-W components of the wind at all upper wind sounding stations and monthly mean pressure heights, potential temperatures and dew points at all radiosonde stations on or near 30°E, 73°E and 140°E for as many pressure levels as possible.

3.1.3.2. Analysis - isotachs of the zonal wind component, isentropes.

3.1.4. Total number of charts in the Atlas - 156.

3.1.5. Comments - since no upper air atlas of the Indian Ocean region at present exists, one is being prepared at the International Meteorological Centre utilizing monthly means of all existing upper wind data, on charts of the area, projection and scale proposed in 2.3.1., 2.4 and 2.5. A preliminary version will soon be given limited distribution and a final version incorporating IIOE data should appear in about two years' time. By using it, investigators would readily be able to determine the anomalousness of the IIOE months.

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* amended to include 100 mb

** " " " about 105-115°E

3.2 Surface Atlas - for every month the sequence of charts, the type of data and methods of analysis will be the same. The chief data sources will be observations made from merchant ships and research vessels. However, whenever possible, observations made at stations on small islands* will be incorporated, care being taken to select only those times of observation at which the local distorting effects of the island are negligible.

Background information

3.2.1. Chart I

3.2.1.1. Plotted data - tracks and dates of all research vessel cruises and research aircraft flights made during the month; tracks and dates of all cyclonic systems which occurred during month, classified according to the following intensity scale:
depression - maximum winds less than 33 knots;
storm - maximum winds between 33 and 64 knots;
hurricane - maximum winds above 64 knots;
frequency of weather satellite photography for each 5-degree square; number of observations made in 5-degree square of 1) sea temperatures; 2) dew points (vapor pressure); 3) air temperatures, surface winds, pressures, cloudiness, weather.

3.2.1.2. Analysis - isopleths of the duration of civil daylight.

Directly observed variables

3.2.2. Chart II

3.2.2.1. Plotted data - monthly mean resultant winds and steadiness; monthly mean pressures.

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* suggested stations

43311	Amini Devi	11° 07'N;	72° 44'E
43368	Car Nicobar	09° 10'N;	92° 50'E
43369	Minicoy	08° 18'N;	73° 00'E
41350	Gan	00° 41'S;	73° 09'E
63980	Mahe (Seychelles)	04° 37'S;	55° 27'E
61967	Diego Garcia	07° 14'S;	72° 26'E
96995	Christmas	10° 25'S;	105° 40'E
61974	Agalega	10° 35'S;	56° 45'E
61968	Glorieuses	11° 33'S;	47° 17'E
96996	Cocos	12° 05'S;	96° 53'E
61976	Serge-Frolow (Tromelin	15° 53'S;	54° 31'E
61986	St. Brandon	16° 27'S;	59° 33'E
61988	Rodriguez	19° 41'S;	63° 25'E
61996	New Amsterdam	37° 50'S;	77° 34'E
68994	Marion	46° 53'S;	37° 52'E

3.2.2.2. Analysis - streamlines, isobars.

3.2.3. Chart III

3.2.3.1. Plotted data - monthly mean air temperatures; monthly mean sea surface temperatures.

3.2.3.2. Analysis - isotherms of air and sea surface temperatures.

3.2.4. Chart IV

3.2.4.1. Plotted data - monthly mean cloudiness; percentage frequency of observations recording rain.

3.2.4.2. Analysis - isonephs; isopleths of rain frequency.

Derived data

3.2.5. Chart V

3.2.5.1. Plotted data - total monthly incoming radiation (insolation minus reflected radiation); number of hours per month in which the incoming visible radiation exceeded 400 lux.

3.2.5.2. Analysed data - isodiabatics; isopleths of total number of hours.

3.2.6. Chart VI

3.2.6.1. Plotted data - total monthly heat exchange between ocean and atmosphere (Q_e and Q_h listed separately at each averaging point).

3.2.6.2. Analysed data - isodiabatics of the total monthly heat exchange.

3.2.7. Total number of charts - 144.

3.2.8. Comments - Several possibilities for special charts remain to be explored. Biologists are interested in the total annual incoming radiation. The relation of low cloud forms to the sign and magnitude of air-sea temperature differences might be represented. Monthly mean vapor pressures should probably be shown, although monthly data may be insufficient and might better be depicted on seasonal charts.

I have not mentioned departures from the long term means. Should they be shown on the monthly charts? If the atlas appears in loose-leaf format with charts of the same projection and scale as those in the U.S. Navy Atlas, investigators could readily determine departures.

I should like also to learn reactions to the idea of plotting frequency curves for small sub-regions with high density of meteorological observations or of observations in other disciplines. As all the meteorological data will be on magnetic tape or punch cards, it would be easy to make special frequency analyses on request rather than undertake the considerable task of including the curves in the atlas.

The same response might well be made to requests for charts showing averages for time-intervals of less than one month. The dangers inherent in averaging very small data samples are of course well known. Special needs, such as those of fisheries scientists for semi-monthly averages, might be met by issuing a set of charts independent of the atlas and in less expensive form.

International Meteorological Centre
Colaba Observatory
Bombay 5
India

C. S. Ramage
17 February 1964

b. Atlas of physical and chemical properties

A brief discussion of the available materials and a tentative outline for an atlas of maps and sections were prepared by Mr. Reid and distributed to the WG for comment. It is reproduced here in a slightly modified form.

Physical and chemical materials

After viewing the available station patterns and noting how many of the cruises have been completed it is possible to list some maps and vertical sections that can be prepared, and to speculate about the feasibility of others. It must be remembered that this evaluation is preliminary. It is only as the maps and sections are prepared that the final evaluation can be made as to whether the data from different vessels are sufficient in quantity, accurate enough, and close enough in time to make the atlas meaningful.

It is useful to have some measure to use in estimating of printing costs of an atlas. For this reason when stating what I believe can be done I have arbitrarily selected a number of properties, maps and vertical sections that might be included in a conventional sort of atlas. This is not meant to place requirements or limitations on the atlas-maker. I believe he should be free to make his own choices in these matters.

A. The Deep Ocean

The large number of measurements in the Indian Ocean will certainly provide adequate materials for an atlas of properties at depths below important seasonal variations. The depth of seasonal variation in the Indian Ocean may be greater than that in the Atlantic and Pacific (particularly in the Somali Current and near the equator). Therefore it is not possible to state how far below the sea surface this "steady-state" atlas may begin. Perhaps the upper limit will be between 500 and 1000 m: in any case it must be determined by whoever prepares the atlas, not by a committee.

1. Maps

Beneath this critical depth it will certainly be possible to prepare the following conventional maps and the other maps of geostrophic flow, transport, depth of density surfaces, etc., that are derived from temperature and salinity measurements.

Maps of properties at intermediate and greater depths in which all data can be used regardless of season:

Depth	Property	Number of levels
abyssal (3500 m and greater), where distribution and circulation are severely limited by bottom topography	temperature, salinity, density, oxygen and other chemical measurements as available	about 6 levels
great depths (2500-3500 m), distribution and circulation still limited by topography	same	about 3 levels

Depth	Property	Number of levels
intermediate depths (700-2500 m), with distribution and circulation less affected by topography	same, plus geopotential anomaly	about 5 levels

2. Vertical sections

Various long vertical sections have been prepared and published already, such as the Vityaz and Ob lines at about 60°E and about 95°E. The complete and self-contained sections laid out systematically should be drawn to a common scale with the interpretation and contouring of each done after comparison of all the sections. Shorter sections and individual stations can be combined to provide various other systematic sections. The exact number of these and their locations can only be settled as the work progresses.

The seasonal aspects need not be considered on a few good, long, deep sections, but it should be possible to make seasonal vertical sections of the upper 1000 m (or as deep as seasonal effects are noted) for much of the ocean.

B. The Upper Ocean

1. Maps

In the upper layers season must be taken into account. In some areas and seasons data seem to be adequate (the Arabian sea, for example) for a thorough seasonal treatment. In others (the Bay of Bengal, for example, and the central South Indian Ocean) situation is doubtful at best, and may depend not only upon all planned cruises being carried out but upon some means of adding to the planned coverage.

Professor Tchernia has indicated a severe shortage of data in the western equatorial region in summer. This may be taken care of by the Argo cruise in the summer of 1964.

It seems reasonably sure that by grouping the data in 6-month seasons they will give reasonable coverage in most areas. The choice of which 6-month periods may be difficult.

The upper layer might be represented by about five levels, with maps at each level showing temperature, salinity, oxygen, phosphate and other chemical properties as available, with calculated values such as density and geopotential anomaly also.

2. Vertical sections

Vertical sections of the upper few hundred meters in different seasons should be used to augment the deep vertical sections. They will be available in many parts of the Indian Ocean. Indeed, in the Arabian Sea there will be perhaps more sections than can be included usefully in a general atlas.

The sections should include the same properties as the maps.

C. Estimate of Number of Maps and Sections

1. The deep-water atlas might include about 14 levels with at least 6 properties, or 84+ maps.

The number of vertical sections might be about 14, with about three of them filling as much space as one map. This would be 28+ map-equivalents.

2. The upper layer atlas might include 5 levels, in two seasons, or 60+ maps. The number of vertical sections might be about 20 in two seasons, but they might be smaller, with about 6 of them filling as much space as one map. This would be 40+ map=equivalents.

3. The total number of maps and map-equivalents would be 212+ for 6 properties. If the atlas size is such that one map fills a page this means 212 pages.

c. Biological Atlases

Vagn Hansen, Curator, I.O.B.C., Ernakulam, S. India and Professor Motoda have discussed this matter and have written at some length about the materials that are available and might later become available. Hansen has written, in part:

"1. Data of only a few of the biological parameters may be available without too much delay (see below) and suitable for processing into atlases. These are:

(a) Zooplankton volume

(b) Chlorophyll (these observations are made and will be made mainly by Australia, Great Britain, Germany, U.S.A., [U.S.S.R.?] and India).

(c) C-14 assimilation (as various methods are used it will be necessary to recompute the results from the expeditions, but this can probably be done. Participants of I.I.O.E.: Australia, Germany, Great Britain, France, S. Africa, U.S.S.R., U.S.A.).

The distribution of these three properties (a, b, c can be trated by:

(i Surface maps: The 3 properties converted into units unit for the monsoon and intermonsoon periods.

(ii) Detailed maps of selected areas with sufficient dense grid of stations (Arabian Gulf, the western part, and eastern part of Indian Ocean, E. of 90° E.).

(iii Vertical sections from selected areas.

Professor J.Krey, subject leader for the I.I.O.E. has compiled all plankton stations and should be a consultant in this respect.

(d) Observations of shoals of scombriform (tuna) fishes

(e) Observations of whales

(f) Observations of birds

Mr. D.N.F. Hall, previous Zanzibar, is Fisheries Subject Leader for the I.I.O.E. and should be consulted on items (d), (e), (f).

2. A characteristic difference in working up physical, chemical and biological oceanography data is that the last mentioned are usually processed with a very considerable delay.

As one of the important types of atlases for biologists will be concerned with zoogeography this means that data on the distribution of specific organisms in the Indian Ocean from the I.I.O.E. will not be available within at least the coming 5 years. We have however one important problem involved at the initial stage of preparation, namely the literature already published on the taxonomy and distribution of marine organisms in the Indian Ocean.

As a bibliography concerned with all species of the Indian Ocean is impossible to make, the groups that are quantitatively most important could be selected and bibliographies as complete as possible should be worked out. For this purpose experienced taxonomists should be considered who could be selected for specific purposes and who should be given economic support for doing the work (steno assistance, etc.): e.g., such scientists as Dr. P.L. Kramp, Zoological Museum of Copenhagen, who privately has a complete bibliography of Medusae, Dr. S.Krishnaswamy, University of Madras, who previously worked in close co-operation with the late Dr. Sewell on copepods from the Indian Ocean, etc.).

The reason why I emphasize the importance of bibliography is:

(a) Very few biologists have a real all-round substantial knowledge on literature of the biology of the Indian Ocean, as it to a large extent is found in older literature or scattered in recent periodicals with limited distributions.

(b) I do think that a considerable part of the material of the I.O.B.C. will be finally processed by experts of the countries surrounding the Indian Ocean. The greater part of the experts in Europe, U.S.S.R. and U.S.A. in the future will have sufficient material from national and international expeditions. As the library conditions in most countries surrounding the Indian Ocean are fairly limited it will be necessary to have established a bibliography of the type described (worked out in U.S.A. and Europe where great libraries are available).

The problem of preparing atlases on zoogeography is as mentioned a future task in which we will be completely dependent on the individual experts of the groups involved. We consequently can't take action according to this now.

3. Limitation of many previous atlases in marine biology: One of the failures in biological atlases giving distributions to organisms has been that the physical and chemical parameters have not been considered (Ekman: Zoogeography of the Sea). In some atlases will be found organisms plotted on a map without consideration of the water type in which they have been living. Unfortunately the standard hauls taken for the I.O.B.C. with the Indian Ocean Standard Net are taken straight from 200 m to the surface. It is consequently impossible to select which organisms have lived above the thermocline and which below the thermocline. I have therefore recommended at the I.I.O.E. Coordinators meeting at Paris in January 1964 an additional haul to be taken from the thermocline to the surface.

4. It would consequently be advisable to have a very close cooperation between biologists and physical and chemical oceanographers, and if a board is selected for preparing atlases there should be one physical-chemical oceanographer to advise the biologists.

5. On the other hand it is very advisable that one or more biologists (just as it is now) inform and advise the physical and chemical oceanographers and meteorologists what type of atlases will be of greatest benefit for the biologists."

Schaefer for FAO Tuna Panel suggests 500 metres.

d. Geological and Geophysical Atlases

Prof. Bezrukov has examined the availability of materials for atlases in these fields and has noted that the exchange of data on the results of the International Indian Ocean Expedition is still inadequate. Exchange of this sort of data is, of course, more complex than merely distributing tabulations of temperature, salinity, etc. It is difficult to state in what areas data are lacking for the compilation of geological and geophysical maps.

He believes it expedient to include maps of bathymetry (one map has already been published), geomorphology, a tectonic map, and maps of bottom sediments and some of the main components such as $CaCO_3$. Bathymetry could be represented by profiles as well as maps. It is too early to make suggestions about geophysical maps for items such as heat flow.

3. The financial requirements for the preparation of Indian Ocean Atlases.

The costs of preparing atlases from processed data can be separated into two categories: preparation of the copy (organizing, plotting, contouring, drafting, etc.) and the printing and binding of the copy. Since the first category will be borne indirectly in some large or small part as the regular work of various institutions it is not possible to state how much money would be required, even if the total amount of labor could be calculated and evaluated. Therefore the cost estimates have been limited to the printing and binding expenses.

Costs have been estimated by referring to two recent Atlases: F. C. Fuglister's Woods Hole Oceanographic Institution Atlas Series Vol. I (printed in the United States) and the NORPAC Atlas (printed in Japan).

These two Atlases, that appeared in 1960, have been appraised in 1964 by commercial printers in Japan and the United States. They indicate that to print 1000 copies of either of these atlases at present rates would cost about $11,000 to $15,000. Costs per copy would be somewhat less if larger numbers were printed.