

fellow at Scripps on an expedition in 1959 to the North Equatorial Current with John Knauss. John told me that if I wanted to be an oceanographer, I had to read *The Oceans* as a start. I didn't do it then, but when I finished my degree in 1962, I joined John for the first cruise of a set of Indian Ocean expeditions. I bought my copy at the Ed-

ucational Book Centre, Ltd in Singapore; it still has the label. It's a well worn "Modern Asia" edition. I hand colored most of the water mass diagrams in Chapter 15, trying to understand how this all worked. Now my library is filled with oceanography texts and research journals, but I have a special place for *The Oceans*.

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## THE OCEAN "BIBLE": REMINISCENCES

By Walter H. Munk

IN 1940, the Director, Harald Sverdrup's\* office occupied the southeast corner on the second floor of George Scripps Hall (now renovated through the efforts of Fred and Sally Spiess). William Ritter, the first Scripps Director, had lived on the second floor, and Harald's office had been Ritter's study and library. Every Tuesday afternoon Harald held "open door" for the affairs of the Institution. This left him with more time for his personal scientific work than most oceanographers at Scripps have today.

There is a nonfunctional fireplace at one end of the office and next to it a door leading to a small room where Harald's secretary, Ruth Ragan, held forth. She had spent 20 years in Japan at the YWCA before taking a job with Harald's predecessor, T. Wayland Vaughan. In addition to typing, proofing, and correcting the manuscript of *The Oceans*, she compiled the bibliographies. Miss Ragan also kept all the Scripps accounts. She once caught me using a Scripps envelope for my personal correspondence, and I received a stern note from HUS.

Harald's office had a small backdoor to the northeast leading into the hall opposite to a room that I occupied. It was summer 1940, and HUS was working on Chapter XV: "The Water Masses and Currents of the Oceans." Harald would appear at my door and say quietly: "come and listen." In the middle of his office there was a big wooden table piled high with books and papers in stacks corresponding to the major ocean basins. Harald would walk slowly around the table, pick

up selected papers from the stacks, and speak out loud on what he thought were the essential features. He would go through this exercise many times following different guide lines. (It was at one of these sessions that he decided to organize the chapter around the Antarctic Ocean, looking at the Atlantic, Pacific and Indian Oceans as northward pointing fingers.) When he was ready he would call in Miss Ragan and dictate a section of the chapter without referring to any notes.

Occasionally he would have me read off numbers for him to plot. Today we have lost the excitement of wondering where the next point will fall. HUS would beam if a point confirmed a developing pattern, and scorn if it missed. Each point was taken seriously, and outliers were often rationalized. This is consistent with the motto expressed in the book's preface: "... we have, however, preferred definite statements to mere enumeration of uncorrelated observations and conflicting interpretations, believing the treatment selected would be more stimulating."

All of HUS writings were led by observational material. Mathematics was used as a concise *a posteriori* discipline for organizing his thoughts, not as a means of deriving new insights. This was also true (but to a lesser extent) of Carl-Gustav Rossby who was visiting at the time. The procedure was in collision with Carl Eckart's *a priori* mathematical deductions and led to great frustrations on the part of Eckart.

Harald Sverdrup (and the rest of us) did not then understand the underlying concepts of continuous spectra as applied to geophysical processes. In a related vein, we did not understand the sampling requirements of continuous band-limited processes, and the resulting aliasing of under-sampled fields. For 100 years every effort at

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\* He was "Dr. Sverdrup" for eight years before he invited me to call him Harald; all his notes were signed HUS.

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increased ocean sampling was followed by an expression of surprise at the resulting complexity of the observed field. George Deacon and Norman Barber in the U.K. had it straight. In his review of *The Oceans*, (*Nature*, 155, 652–654, 1945) Deacon remarks on the “. . . frequent insistence . . . for additional observations. . . . Where measurements have been made synoptically, over a dense network of observation points, the irregularities in physical properties and water movements have proved much greater than was expected, and they show that great caution must be exercised in drawing conclusions from scattered observations.” Not even the uncommon common sense of Harald Sverdrup could overcome the unforgiving demands of the sampling theorem.

Of all the reviews in the Scripps Archives, Deacon's is the most critical and informed; the rest are uniformly favorable, with two exceptions. On p. 592, the discovery of internal waves is attributed to Helland-Hansen and Nansen. V. Walfrid Ekman in his review (*Nature*, 155, 669, 1945) writes that “. . . such waves were discovered . . . by the nestor of Swedish Oceanographers, the late Otto Pettersen . . . (who) also proved their tidal periodicity.” Pettersen discovered internal tides in 1909. But Sverdrup *et al.* were referring to non-tidal variations observed during the 1893–96 voyage of the *Fram*. Nevertheless, Hans Pettersen (Otto's son) was still fuming when I met him in Göteborg in 1948: “There are three ways for people to detract from original contributions” he said, “by claiming them to be false, to be trivial, or to have been done before, and sometimes they claim all three.”

Rear Admiral G.S. Bryan, Hydrographer of the U.S. Navy, (*U.S. Naval Institute Proceeding*, August 1943) had a more serious criticism: “. . . it is regretted that very little credit has been given to the U.S. Navy and the Hydrographic Office for the original development of sonic sounding, for their major contribution of deep-sea soundings throughout the world, and for their comprehensive data on ocean currents. The reviewer has also looked in vain for even a mention of the name of the man who was practically the first to focus attention of the scientific world on the study of oceans—Matthew Fontaine Maury.” This was clearly an oversight, and I think it arose from Harald's limited interest in the history of things and who got credit for what. I often heard him talk of discoveries, but seldom about the personalities behind the discoveries. George Deacon in the *Nature* review previously cited said: “Oceanography has advanced too rapidly in the twentieth century to allow its textbooks to include an adequate treatment of historical aspects. It would be a very good thing if a history of the subject could be written. . . .” As it turned out, it was Sir George's daughter Margaret who has so ably fulfilled these wishes.

The first printed copies of *The Oceans* arrived in La Jolla on 19 December 1942. That evening, all the people who had been involved in its preparation celebrated at the Sverdrup home. This included E.C. LaFond who had prepared all the illustrations for Sverdrup and Fleming; Johnson did his own. Alice Fleming (the widow of Richard Fleming) recalls separate champagne toasts “to the readers,” “to the authors,” “to the wives of the authors” (in order of decreasing benefit). It was that night the book was christened “The Bible.” It was also Miss Ragan's first-ever sip of wine. There followed an incredible delay in the distribution abroad. In a letter to Sverdrup of 2 March 1943, G.A. Morris of Prentice-Hall (the publisher) wrote, “After much debate between the New York Branch (of the Board of Economic Warfare) and the head office in Washington, we were informed that *The Oceans* was not to be sent anywhere outside the continental United States. . . . I then submitted the book to the Navy Department, which has just phoned me that it would be of great aid to the enemy should it fall into his hands.” The book did not become available abroad until VE day in May 1945, but an earlier copy had been hand-carried to England by the Hydrographer Vice-Admiral Sir John Edgell and reviewed by J.N. Carruthers (*Q. J. Roy. Met. Soc.*, 70, 159–160, 1944). By VE day, Carruthers was on a mission to Berlin to save the last remaining Richter and Wiese reversing thermometers from falling into Soviet hands.

I have often wondered what made Harald agree to write the book in the first place. Miss Ragan recalls that Harald was about to turn down the request by Prentice Hall to prepare the book when she said: “why don't you do it” and he said, “alright, I will.” The contract was signed on 20 September 1938 for completion by 1 November 1939! It called for 500 to 600 printed pages; the book ended up with 1,087 pages. According to Martin Johnson, “This increase in length led to some grumbling by the publishers, but they relented and agreed to publish at a loss if necessary.” The contract provided for a royalty of 10% (or 27¢ to each author for the copy I purchased in 1943). Harald had estimated a market of 550 copies; by the end of 1965, 23,766 copies of the American edition alone had been sold.

I have often wondered how Harald chose his coauthors. Harald and Roger Revelle were very close, but Ellen Revelle does not recall any discussions of a possible collaboration; it may have been in Harald's mind that Roger was not known for prompt publication of his work.

As it was, Harald found it hard-going, as related in letters to Hans W. Ahlmann, “This textbook in oceanography . . . must be finished now, so I'm working like a horse. . . . But the book will be fairly good, I hope, even though it will not resemble any prior existing textbook.” (September

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1940). “. . . the oceanography book . . . has hung as a sword of Damocles over my head for several years . . .” (December 1941). “It is a volume of nearly 1,100 pages, which I hope will remain a standard work for some years to come. I cannot send you a copy now . . .” (March 1943). “I would greatly appreciate it if you would send me Ekman’s review of it. Up til now its been reviewed primarily by biologists or geographers, who have not been especially competent on matters of physical oceanography. There has therefore not been especially much discussion of my effort to treat the masses of water and currents in the ocean from a unified perspective.” (November 1945). What made Harald undertake this bruising task? I believe the answer must be that he felt compelled to demonstrate the underlying unity of oceanography, its physics, chemistry, biology, and geology, a conviction he developed during seven years of arctic exploration aboard the *Maud*.

If I were to review my copy of “The Bible” after 50 years of use, I would have to say that it has not stood up at all well. The back cover is barely attached, and some of the fold out charts remain connected to the rest of the book only by repeated applications of sticky tape. But then, what can you expect for 135.9 pages per dollar?

#### Acknowledgements

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I am also indebted to Robert Marc Friedman for the following quotations from letters to the

Swedish glaciologist Hans W. Ahlmann (Ahlmann Collection, Center for History of Science, Royal Swedish Academy of Sciences, Stockholm). The 1940 quote in the next-to-last paragraph is a translation by R.M.F.



Harald U. Sverdrup

. . . chapter XV . . .  
was Sverdrup’s  
greatest contribution to  
oceanography.

## PHYSICAL OCEANOGRAPHY IN *THE OCEANS*

By Bruce A. Warren

COLUMBUSISELIN used to say that Chapter XV of *The Oceans*, “The Water Masses and Currents of the Oceans,” was Sverdrup’s greatest contribution to oceanography. It was a masterful, monumental synthesis of information, and it formed a comprehensive account of the physical features

of the whole world ocean. The only previous work of comparable scope was Krümmel’s *Handbuch der Ozeanographie*, but that was much more a compilation of observations than a synthesis. Sverdrup’s style was forthright and decisive, exemplifying the attitude expressed by the book’s authors in their preface: “we have . . . preferred definite statements to mere enumeration of uncorrelated observations and conflicting interpre-

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