

A PREFACE TO MRI ISSUE
“OCEANOGRAPHY OF THE INDONESIAN SEAS”

KLAUS WYRTKI AND THE MODERN ERA OF THE MARITIME
CONTINENT OCEANOGRAPHY

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ABSTRACT

The December 2019 issue of Marine Research in Indonesia on “Oceanography of the Indonesian Seas” is dedicated to Klaus Wyrtki. In many ways, Klaus Wyrtki’s contribution to the study of the Indonesian seas served as a smooth transition from the era of the great expeditions such as the Dutch Willebrord Snellius Expedition (1929-1930; see Wüst, 1964; van Aken, 2005) of the early and mid-20th century to the modern era.

In the NAGA Report (Wyrtki, 1961; also see Wyrtki, 2005), Klaus used existing ocean observations, supplemented with data he helped collect on the Indonesian research ship *Samudera* during his sojourn in Indonesia (1954-1957) as Head of the Institute of Marine Research in Jakarta to map out a broad view of the Southeast Asian waters (the waters of the Maritime Continent including the Indonesian seas). He presented the geography, the configuration of the seas and basins of the Southeast Asian waters, the surface circulation, and governing dynamics, including the tides and monsoonal driven seasonality, and the temperature/salinity surface layer patterns, as well as aspects of the subsurface stratification. The Plates 1-44 beautifully reveal the oceanographic condition of the Southeast Asian waters as resolved by the pre-1960 observations.

As Klaus Wyrtki says in the NAGA Report Preface: “It is hoped that workers in the region, whether in oceanography or other branches of science may find it a source of information and a stimulus to undertake further research in these waters” and “The scientific publications dealing with this region show not so much a lack of observations as a lack of an adequate attempt to synthesize these results to give a comprehensive description of the region.” “I soon decided to devote most of my time during my three years’ stay in Indonesia to the preparation of a general description of the oceanography of these waters.” He succeeded.

Keywords: Klaus Wyrtki, oceanography, Indonesia, maritime continent, Indonesian Throughflow.

THE INDONESIAN SEAS AND ITS
THROUGHFLOW

The Indonesian seas are at the center of the ascending branch of the atmospheric Walker Circulation, a critical component of the El Niño-Southern Oscillation (ENSO) and Asian monsoon systems. The complex array of basins and passages provide an oceanic pathway for tropical Pacific water masses to reach into the Indian

Ocean, representing only tropical interocean link, enabling the Indonesian Throughflow (ITF) – a key component of the larger-scale ocean and climate systems (Gordon, 2005; Gordon *et al.*, 2010a; Sprintall *et al.*, 2014). Energetic wind and tides elevate the mixing within the Indonesian seas, boosting vertical heat, freshwater and nutrient fluxes, with impact on the climate and ecosystem (Field and Gordon, 1992, 1996; Gordon *et al.*, 2010a; Koch-Larrouy, 2010; Ray

and Susanto, 2016). The ITF varies across a wide range of time scales, from intraseasonal to seasonal (monsoonal) and interannual (ENSO), reaching to century and longer time scales, and will likely play a key role in the nature of the changing climate and marine ecosystem for the Maritime Continent and larger regional to global scale.

Beginning in the 1980s, there has been increasing interest in the oceanography of the Indonesian seas, as its global significance was more widely recognized (Gordon, 1986a,b). There was the Lombok Strait research of Murray and Arief (1988) and Arief and Murray (1996); the Snellius II Expedition 1984-1985 focused on the eastern Indonesian seas (van Aken *et al.*, 1988; van Bennekom, 1988). The Arlindo 1993-1994, mapped the patterns of the ITF during winter and summer monsoon (Gordon and Fine, 1996; Ilahude and Gordon, 1996) pointing the way for configuration of mooring arrays to capture the temporal dimension. Arlindo 1996-1998 initiated the time series of the Makassar Strait throughflow, the primary component of the ITF, continues today (Gordon *et al.*, 2019).

Sprintall *et al.* (2019) review ITF research for Ocean Obs 2019 – an update of the Ocean Obs 2009 review by Gordon *et al.* (2010b), serves as an excellent overview of recent progress and points the way for continued observational and model-based research. The first comprehensive simultaneous measurements of the velocity and property variability in the major inflow and outflow ITF passages were collected over 3 years (2004-2006) as part of the International Nusantara Stratification and Transport (INSTANT) program. INSTANT measurements provided an estimate of ITF transport about 30% higher than estimates made from non-simultaneous measurements prior to INSTANT. The observations also confirmed the Arlindo results that the strongest velocity, the velocity-maximum (V_{\max}), was not within the warm sea layer, but within the cooler upper thermocline. There was the extensive INDOMIX program in the eastern seas (Koch-Larrouy *et al.*, 2010, 2015), and time series of the inflow to the eastern seas via the Maluku Channel (Yuan *et al.*, 2018).

As mentioned above, the longest, sustained monitoring of the ITF is from Makassar Strait. The Makassar Strait throughflow (Gordon *et al.*, 2019) of ~12 Sv, representing ~80% of the total ITF, displays fluctuations over a broad range of time scales, from intraseasonal (Madden Julian Oscillations, Rossby and Kelvin Waves; Napitu *et al.*, 2019; Pujiana *et al.*, 2019) to seasonal and interannual (ENSO) scales. We now have 13.3 years of Makassar throughflow: November 1996 - early July 1998, January 2004 - August 2011, and August 2013 - August 2017. The next mooring rotation may take place in mid to late 2019. Southward transport displays a strong seasonal signal that is strongest in boreal summer as well as interannual variability that scales roughly to ENSO with the weak southward flow with a deeper velocity-maximum during El Niño and stronger southward flow with shallower V_{\max} during La Niña. The southward flow relaxed in 2014 and more so in 2015/16, similar though not as extreme as during the El Niño event of 1997. In summer 2017, there is a return to the non-El Niño state. Since 2016, the deep layer 300-760 m (Makassar Strait sill depth is ~680 m) southward transport increases, almost doubles to ~7.5 Sv. From mid-2016 into early 2017, the transport above 300 m and below 300 m is about equal, where they usually have a ratio of 2:1. In early 2017, the total Makassar transport increases to 'historical' highs of over 20 Sv.

Observing, as well as to simulate within numerical models the complex oceanography of the Indonesian seas is a challenge must be met so as to better predict large scale ocean and climate conditions, as well as regional oceanography within the Indonesian seas. Coordinated international collaborations will move us forward. Sprintall *et al.* (2019) provide in the section "Final Thoughts and Recommendations" ideas for future observations using new technologies, stating: "So, while the convoluted bathymetry of the Indonesian seas means that moorings will likely continue to be the workhorse of any backbone transport array for the near future, our sustained array will propose a multi-platform approach including additional surveys, process studies and new technology that will go some ways to fill in the gaps that cannot be accomplished through moored arrays alone."



Figure 1. Klaus Wyrcki onboard *Samudera*. Image from H. von Storch, J. Sündermann and L. Magaard (1999) “Interview with Klaus Wyrcki, 25 February 1999, GKSS, ISSN 0344-9629.

KLAUS WYRTKI CONTRIBUTION

Klaus Wyrcki has made broad, insightful contributions to our understanding of the global ocean (see the appended Biographic Summary and Publication Citations from Google Scholar). Many know of Klaus for his groundbreaking ENSO research, but his reach is far greater. His 1961 article on ocean thermohaline circulation and his 1962 article on the ocean oxygen minimum relationship to circulation, are remarkable insightful studies, trailblazers. I encourage the new generation of oceanographers to read them. His work on the tropical ocean goes beyond that directly related to ENSO. Of particular note is his work on the oceanography of the Maritime Continent. Even before his famous NAGA Report of 1961, he published 6 papers on the Southeast Asian waters between 1956 and 1960. In 1971, he published the “Oceanographic Atlas of the International Indian Ocean Expedition,” as well as identifying an equatorial jet in the Indian Ocean (Wyrcki, 1973) now referred to as the Wyrcki Jet.

I consider Klaus to be one the Greats in Physical Oceanography. With few data points, his creativity and intellect put together the story of the ocean. Read the wonderful, informative interview of Klaus Wyrcki on 25 February 1999 by H. von Storch, J. Sündermann and L. Magaard, which can be found at http://www.soest.hawaii.edu/Wyrcki/interview_wyrcki.html.

Quotes from the interview that are worth remembering: “Regarding the causes of scientific progress: funding, opportunity, people and coincidence. *Gelegenheit ist Zufall* (Opportunity is chance; *ALG: I call this serendipity*), it is certainly not planned. The progress in science, I do not think is planned. It happens when certain problems are ripe for a solution. Most people will say that progress in the sciences happens through logical thinking. This is certainly an important ingredient, but I strongly believe that most progress is due to imagination and intuition, much like art is being created. Logical thinking and experimentation are of course very important in confirming and solidifying the ideas born by intuition and imagination.”

Klaus heard of a job opening in Indonesia. He says: “I wrote to Indonesia, a few months later I was on the way to Indonesia. This went all pretty easy. When I arrived in Indonesia, they were phasing out the Dutch at that time and they were looking for other people. Since Germany had no colonial attachments, we were somewhat welcome in these countries. In Indonesia, I found myself not only the only scientist in the institute because all the Dutch had left, but I was also the director of it. I had a research vessel of about 200 tons, a nice yacht type vessel, the *Samudera*. I made many voyages with it, with very little instrumentation. We did a few surveys with Nansen bottles down to a few hundred meters but could not reach the deep-sea basins in Indonesia

because of a lack of a long wire, and that restricted us to the surface layers. I discovered there was a lot of actual information about these waters that had never been summarized. I started to work on a book, the physical oceanography of the Southeast Asian waters; it became known as the NAGA Report later on when it was published at Scripps. I wrote that book on many long voyages through the Indonesian waters.”

When analyzing the data from both the Dana and the Snellius expeditions, the Snellius expedition was not completely published by that time. I could analyze existing sea level data, I could make dynamic calculation, both in the Pacific and in the Indian Ocean. I could identify the fact that there was a pressure difference between the two. I analyzed surface circulation, which indicated that there was a monsoon dependent throughflow. That was the start of that type of research.

I found this quote to be particularly interesting: “What came nearest to a book was the NAGA Report, which you may call a monograph; also the Indian Ocean Atlas is a big piece of work. I intended to write a book with the title ”The Water Masses and Circulation of the Indian Ocean,” and I gave it up since it takes about five to six years to write and by that time much of the information is superseded by new knowledge. Knowledge is accumulating these days at a rate that you can say after a decade, things are old. That’s too short a lifetime for a book.”

After Indonesia, Klaus Wyrтки moved to CSIRO in Australia where he stayed until 1961. He had heard that “the people at Scripps want your curriculum vitae. I sent them my curriculum vitae. Of course in the curriculum vitae you had to give references. One of the references was Georg Wüst, who at that time was at Columbia University. After about two weeks, I got a job offer from Columbia University.”

ABOUT PROF. DR. GEORG WÜST

In the 1999 interview, Klaus Wyrтки often mentioned Prof. Dr. Georg Wüst, who served as his Ph.D. advisor. I too studied under the supervision of Georg Wüst, when he was a visiting professor at Columbia University in 1960-1964 after his retirement from Kiel University in 1959. He returned to Germany in 1964 to a visiting professorship at the Institute

of Meteorology of the University of Bonn. In 1967, he moved to a retirement home with his wife Mimy (and their dog Whisky) in Erlangen, Germany. I often visited Wüst in Erlangen, and we exchanged frequent letters until his death on November 1977. He spoke of Klaus Wyrтки, his first student after World War II. Klaus enrolled at the Institut für Meereskunde of the University of Kiel graduate program with its new Director Georg Wüst in 1948. Wüst recalled to me that Klaus rode a loud motorcycle. In July 1971, Klaus visited Georg in Erlangen along with his wife and daughter and presented him with a copy of his Oceanographic Atlas of the Indian Ocean.

Klaus Wyrтки said in the 1999 interview: “At Scripps, I would belong to a tuna research program that stretched all the way from California to Peru, throughout the eastern tropical Pacific investigating the environment of the tuna population. At Columbia, I would be assigned to a new research ship, the Eltanin, and I would go into the Antarctic Ocean. Arnold Gordon eventually got the job, because I said, no, no. No Antarctic Ocean, no seasickness, no roaring forties, I stay in the tropics.” After Indonesia I was spoiled, I didn’t want to go back to the cold climate, so Scripps institution won. “Wüst was disappointed, of course, but he got Arnold Gordon. That was fine.”

I thank Klaus Wyrтки for opening up an opportunity for my career. I find it interesting that after my Southern Ocean work, I too moved to the warmer climate of Indonesia. Klaus was right, as usual.

In the 1999 interview, Klaus says: “You asked what I learned from Wüst. It’s basically the general overview, to look at large connections, not at the details, but to integrate things, to see the big picture. Somehow that was the message I too received from Wüst. Though I must say, I am glad that many oceanographers do closely look at the details.

CONCLUDING COMMENTS

Klaus Wyrтки: “I have no regrets about the things I have done. I have enjoyed the scientific career that I have made. I would do the same thing, it may not turn out the same way because we are subject to chance, you know, but basically I would do the same. I agree - Well Done, Klaus!

BIOGRAPHICAL SUMMARY KLAUS WYRTKI

Born: February 7, 1925 in Tarnowitz, Germany
Married. Children: daughter born 1954; son born 1962
Naturalized U.S. citizen, January 5, 1977

Education

University of Marburg, Germany, 1945-48
Mathematics, physics, geography

University of Kiel, Germany, 1948-1950
Oceanography, physics, mathematics

May 20, 1950 - promotion to Doctor of Natural Sciences with Magna Cum Laude

Experience

- 1950-51 German Hydrographic Institute, Hamburg
- 1951-54 German Research Council, post-doctoral Research Fellowship at the University of Kiel
- 1954-57 Head of the Institute of Marine Research, Djakarta, Indonesia
- 1958-61 Commonwealth Scientific and Industrial Research Organization, Division of Fisheries and Oceanography, Sydney, Australia; Senior Research Officer; later, Principal Research Officer
- 1961-64 University of California, Scripps Institution of Oceanography; Associate Research Oceanographer; Research Oceanographer
- 1964-92 University of Hawaii, Professor of Oceanography
- 1993 University of Hawaii, Professor Emeritus

Membership in Professional Societies

American Geophysical Union
American Association for the Advancement of Science
American Geographical Society
American Meteorological Society
Hawaiian Academy of Science
The Oceanography Society Pacific Science Association

Professional Activities

Editor of Atlas on Physical Oceanography of the International Indian Ocean Expedition
Member, Editorial Board, Journal of Physical Oceanography 1971-79
Chairman, North Pacific Experiment (NORPAX) 1974-1980
Member, SCOR Working Group on the Prediction of El Niño
Member, Science Working Group on the Topography Experiment (TOPEX)
Chairman, IAPSO Committee on Climate Changes and the Ocean
Member, NOAA Panel on Climate and Global Change

Invited speaker at numerous international and national symposia and conferences.

Participant in numerous international conferences and member of scientific panels of international organizations such as:

Intergovernmental Ocean Commission (IOC)
World Meteorological Organization (WMO)
International Oceanographic Data Exchange (IODE)
UNESCO Special Committee on Ocean Research (SCOR)
International Association of the Physical Science of the Ocean (IAPSO)

Awards

Excellence in Research Award, University of Hawaii, 1980
 Rosenstiel Award in Oceanographic Sciences, University of Miami, 1981
 Fellow, American Geophysical Union, 1982
 Maurice Ewing Medal, American Geophysical Union, 1989
 Fellow, American Meteorological Society, 1991
 Sverdrup Gold Medal, American Meteorological Society, 1991
 Achievement Rewards for College Scientists, ARCS Foundation Inc., 1991
 Albert Defant Medal, Deutsche Meteorologische Gesellschaft, 1992

Provided by Margaret Swan

KLAUS WYRTKI PUBLICATIONS

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