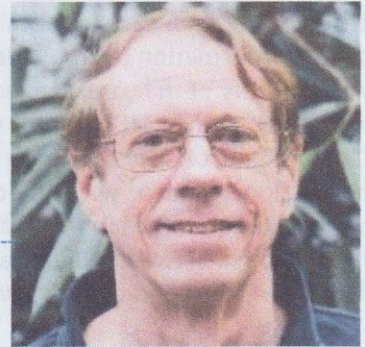


## REEFLECTIONS

# From Reef Science to Reef Action

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The author, from his book "In Pursuit of Hope" (2019)

As a budding marine botanist, my interest in coral reefs began as a Visiting Postdoctoral Research Associate at the National Museum of Natural History, Smithsonian Institution in Washington, D.C. in 1969. With no ocean nearby, it seemed logical to go south to the tropics. I originally intended to work at the Smithsonian Tropical Research Institute in Panama, but the Governor of American Samoa asked for help in understanding the environmental problems of his territory, so I went there and surveyed the reefs around the islands. I found in the Smithsonian library a voluminous report of the Carnegie Institution's expedition to American Samoa led by Alfred Mayor in 1917-1920 (see Mayor 1918), with detailed descriptions of a quantitative transect survey across the reef in Pago Pago harbour. I was able to relocate the site of the transect, and repeat the survey twice that decade, so as to study the reef dynamics. This has since been followed up (Birkeland et al. 2013), providing almost a century of data about that particular reef.

One other interesting experience that initiated my interest in global environmental governance was the opportunity to represent the Bahá'í International Community at the 1972 United Nations Conference on the Human Environment in Stockholm, the meeting that founded the United Nations Environment Programme (UNEP). Since my faith tradition, the Bahá'í Faith, emphasizes unity in diversity, I wanted to understand what nature could teach us that might be relevant to human society. So I set out to study the complex ecosystem that is a coral reef.

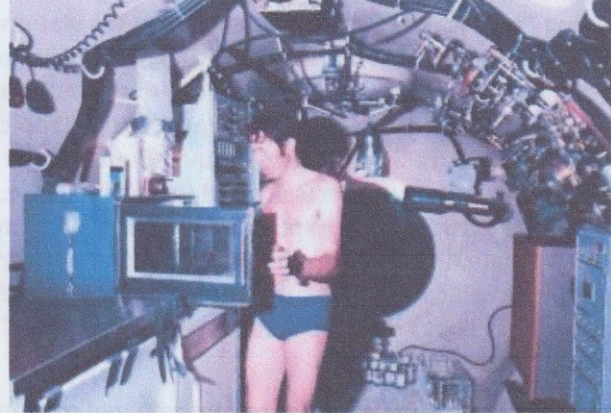
There were two other young coral reef scientists at the Smithsonian at the time: geologist Ian Macintyre (a past ICRS President and Darwin Medal winner) and zoologist Klaus Rützler. Along with Steve Smith, we organised an NSF-funded research project, Comparative Investigations of Tropical Reef Ecosystems (CITRE), involving 80 reef specialists, intending to build a quantitative systems model of the coral reef ecosystem. We held a workshop on Glover's Reef off Belize, and mapped out a grid of 104 compartments, with diagrams of the expected interactions among all the compartments, and then engaged with a modelling team at MIT to prepare a dynamic systems model. With Arnfried Antonius (probably the first person to begin describing then evident coral reef diseases), I dove on coral reefs all over the world looking for the best locations for data collection. We published our conceptual work in the *Atoll Research Bulletin* in 1974, but could not go further. However, we did establish a research laboratory on Carrie Bow



Pago Pago in American Samoa, where Mayor completed his historic reef transect during 1917-1920.

Cay on the Belize Barrier Reef to continue the work and this lab continues to operate today. This was an exciting time in coral reef research, networking with scientists around the world.

This work was an early application of the rapidly evolving field of complex systems science being enabled by new information technologies. This is particularly appropriate to understand both the resilience and vulnerability of the coral reef ecosystem with thousands of species and high integration. The computer modelling team at MIT that we worked with had just published, in 1972, a highly influential report for the Club of Rome on *The Limits to Growth*, with scenarios showing that unlimited growth in the economy, population, resource use and pollution would lead to the collapse of civilisation in the mid-21<sup>st</sup> century. All of my subsequent work was guided by this framework of systems thinking, understanding the relationships between all of the parts, the flows of energy and information, the dynamics over time, and the role of rules and values, governance and other outside factors in determining system behaviour.



Left, participants at the Glover's Reef workshop. Right, working in the PRINUL undersea laboratory (1972).

Another interesting opportunity from those years was to be an Aquanaut studying reef algal ecology in a two-week saturation diving mission in the Puerto Rico Inter-National Undersea Laboratory (PRINUL), 20 meters down on the base of a coral reef. I noticed a huge difference between a two-hour visit and two weeks' residence. The fish got to know us and would follow us around. One significant result of my continuing work on marine algae was a paper showing how the coral reef community created a large functional surface area many times its horizontal surface, which enabled the reef system to both absorb more light and catch more food (Dahl 1973). I was learning the advantages of complex systems science as a tool for a more integrated and functional perspective on such a complex ecosystem.

At about this time, I also had the opportunity to attend the memorable Second International Symposium on Coral Reefs, held on the cruise ship *M.S. Marco Polo*, as she sailed up and down along the Great Barrier Reef of Australia. We had a post-symposium field trip to visit reef habitats in Fiji, staying in a local village on an outer island. Subsequently, I was also able to examine reef sites in Guam, Palau and Hawaii. This research was my introduction to complex systems thinking for unity in diversity based on cooperation and symbioses, which I extended to human systems and the challenges of global governance later in my career.

The early 1970s also saw the rise of the environmental movement around the world and increasing evidence of environmental damage and the need for management action. I had already experienced the Santa Barbara oil spill in 1969, and lectured at the first Earth Day in Washington, D.C. in 1970. Since childhood, I had dreamed with my Bahá'í values of being of service in poor developing countries. That opportunity came in 1974, when the South Pacific Commission in New Caledonia (SPC, now the Secretariat of the Pacific Community) offered me the post of Regional Ecological Adviser to all 22 Pacific Island countries and territories. I chose action over research, resigned from the museum, and moved to Noumea.

That first year, I visited almost all of the Pacific Island countries to determine their needs, and was also able to visit organizations like UNEP in Nairobi, the International Union for the Conservation of Nature (IUCN) in Switzerland, and others in the United States. For the next eight years, I assisted island countries with everything from primary school curricula to creating national parks and reserves, training

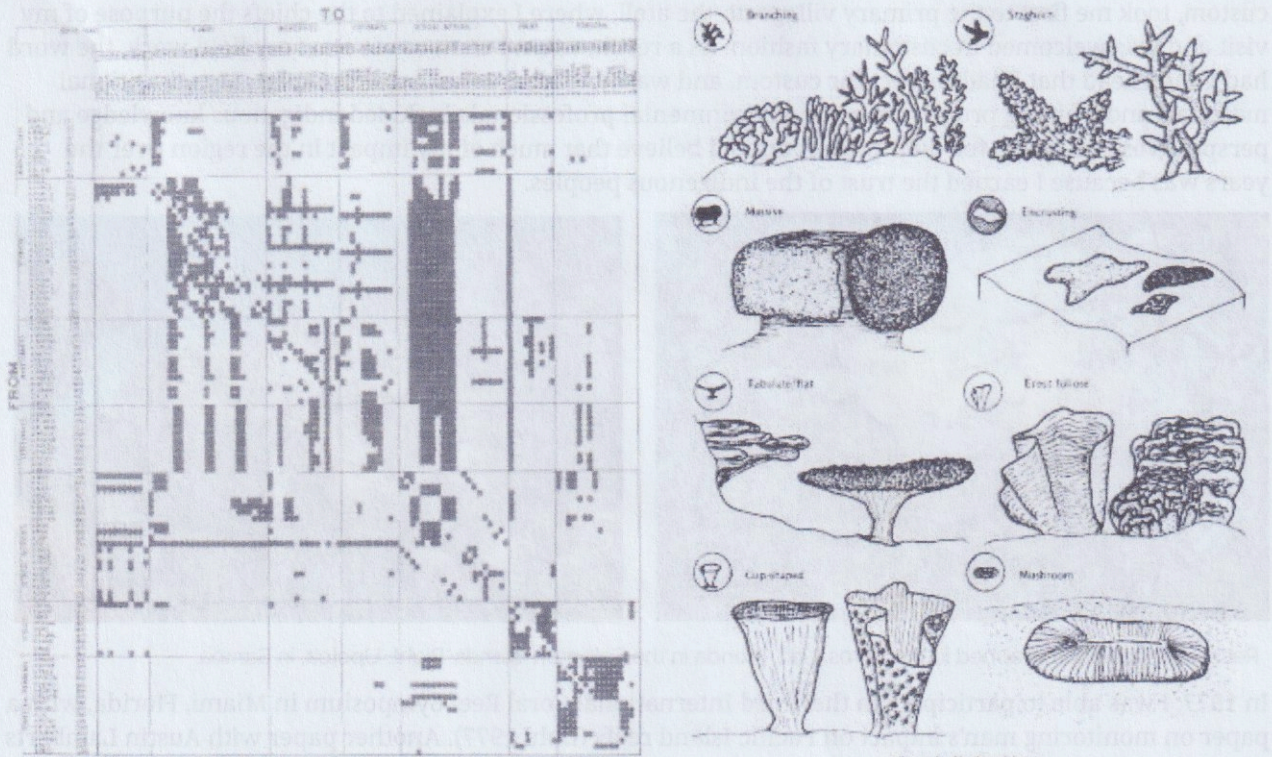


Figure 4. Hard coral forms

Left, expected interactions among compartments in the model. Right, coral life-forms proposed for reef monitoring work.

environmental planners, surveying the different ecosystems of the region, organizing scientific meetings, adopting a Convention on Conservation of Nature, and finally planning and launching the South Pacific Regional Environment Programme (SPREP), adopted by UNEP as a Regional Seas Programme, that eventually separated from SPC to become its own intergovernmental organization, the Secretariat of the Pacific Regional Environment Programme, based in Apia, Samoa.

During this work I learned a lot about the Indigenous Knowledge of local people, that was often far ahead of Western science. A first example came to light after the Solomon Islands government asked me to investigate a fisheries management problem in the Langa Langa Lagoon, on the island of Malaita. The fishermen lived in villages constructed on artificial islands in the lagoon, and made local traditional money from different shells, including one with a band of orange across it that was subject to overfishing. The local Bahá'ís took me to meet the old pagan priest who traditionally managed the shell fishery. He did this by placing taboos on different parts of the lagoon until he received pigs to sacrifice. Then, after holding traditional ceremonies, he would lift the taboo on collecting shells in one section of the lagoon. With more pigs, he would lift the taboo on another section of the lagoon. Normally, each taboo would last 4-5 years, enough time for the shells to reach the right size to harvest. Thus, the periodic taboos served as an excellent fisheries management technique.

Pigs, in local custom, had great value; they were the equivalent of a “gold standard” in traditional money. However, since World War II, most of the villagers had become Christian or Bahá'í and so no longer believed in giving pigs for sacrifice. So the priest had kept the taboo in place for 30 years, and the system had broken down. I met with the fishermen, explained the wisdom behind the traditional taboo system, and encouraged them to close and open parts of the lagoon to shell collecting in the same way, so as to maintain the productivity of the resource.

The Pacific Islands and their indigenous inhabitants have been fortunate to retain many of their traditional cultures and worldviews despite the heavy impact of colonisation. I was able to live more than a decade among islanders at a time when many island countries were newly independent, allowing me to appreciate deeply what they could offer to the world, which resonated with my own Bahá'í spiritual tradition. For the Pacific peoples, the environment is not something external, but is part of their own being. On my first visit to Kiribati, the government arranged my programme, but the local Bahá'ís, to respect their

custom, took me first to the primary village on the atoll, where I explained to the chiefs the purpose of my visit and was welcomed in customary fashion. As a result, when I went out to start my field work, the word had gone ahead that I had respect for custom, and was not just another outside expert. My educational materials and training programmes for environmental professionals included indigenous knowledge and perspectives and called for their preservation. I believe that much of my impact in the region over the years was because I earned the trust of the indigenous peoples.



Research sites photographed in the 1970s. Left, Munda in the Solomon Islands. Right, Upoloo, in Samoa.

In 1977, I was able to participate in the Third International Coral Reef Symposium in Miami, Florida, with a paper on monitoring man's impact on Pacific Island reefs (Dahl 1977). Another paper with Austin Lamberts described what we had learned from our reef monitoring in American Samoa and our resurvey of Mayor's 1917 transect, demonstrating the major changes in coral cover that can occur in response to environmental impacts (Dahl & Lamberts 1977). To make scientific methods more accessible to reef users for participatory science, I organized and directed an Expert Meeting on Coral Reef Monitoring, on Motupore Island, Papua New Guinea, which led to a first simple *Coral Reef Monitoring Handbook* (Dahl 1981b), which was reprinted by UNEP in their Methods for Marine Pollution Studies series, becoming widely used. Soon enough, the 4th International Coral Reef Symposium came around (in Manila, Philippines) and I published a widely cited paper on monitoring coral reefs for urban impact (Dahl 1981a). Perhaps of even greater significance, I became a founding member of ICRS (then the International Society for Reef Studies).

My efforts to build governmental interest in environmental management culminated in 1982 when I organized and directed a ministerial-level *Conference on the Human Environment in the South Pacific* in Rarotonga, Cook Islands, as the political launch of the Pacific Regional Environment Programme. While the small island countries had too few human resources for all the scientific competencies necessary for environmental management, together they could pool resources to achieve a critical mass. A decade later I was able to scale this to the global level.

One of the most meaningful experiences during my years in the Pacific Islands was to discover and then support, across many island cultures, indigenous traditional knowledge of the island environment and its natural resources. While much has been lost under colonisation, there is still great wisdom that is highly relevant to achieving a sustainable future in limited island environments. Living in New Caledonia for more than a decade, and cultivating a respectful relationship with the Kanak people (assisted by my many Bahá'í friends among them) I was able to prepare an account of traditional environmental management knowledge (Dahl 1985a), as well as review the challenge of conserving and managing coral reef ecosystems (Dahl 1985b).

At the 5th International Coral Reef Congress in Tahiti in 1985, I organised and chaired a symposium on the *Protection and Conservation of the Reef Environment, A Gamble on the Future*. This led to publication with Michel Pichon of both an introduction to the symposium (Dahl & Pichon 1985), and the symposium conclusions (Dahl 1985b). Likely in consequence, in 1986, UNEP asked me to help re-establish its Regional Seas Programme as the Oceans and Coastal Areas Programme Activity Centre in Nairobi, Kenya, after its transfer from Geneva. Subsequently, I became Deputy Director of the UNEP Oceans and Coastal Areas

Programme, helping countries around the world to protect their oceans and coastal areas, and supervising Regional Seas Programmes involving 140 countries around the Mediterranean, the Red Sea, the Persian/Arabian Gulf, East Africa, West Africa, South Asia, South-East Asia, my own programme in the South Pacific, the South-East Pacific along Latin America, and the Caribbean.

When the UN was organizing the United Nations Conference on Environment and Development (UNCED), the so-called “**Rio Earth Summit**” of 1992, I was seconded to the secretariat and was responsible for the drafting and negotiation of Chapter 17 of its action plan *Agenda 21* on the “Protection of the oceans, all kinds of seas, and coastal areas and the protection, rational use and development of their living resources” (UNCED 1992). I was specifically requested to include a section on Small Island Developing States (SIDS), helping to launch the concept. While island countries had individually seemed marginal at the United Nations, together they represented over forty votes in the General Assembly and found an important place at the table that has continued until today. My experience in enabling islands to see what they had in common across the Pacific could now be applied at a global level. Since most SIDS have coral reefs and are threatened by climate change-linked coral bleaching and sea level rise, they have become important global actors for reef protection.

My career took a broader turn in 1992, when I moved to Geneva as Coordinator of the UN System-Wide Earthwatch, and also became Deputy Assistant Executive Director of the UNEP Division of Early Warning and Assessment. One responsibility was to develop indicators of sustainable development that governments could use to measure progress, so I helped to lead that process, both within the UN, and through the then influential Scientific Committee on Problems of the Environment (SCOPE). This became my major activity over the next decade and beyond.



In the UNEP office in Nairobi, 1991

Another interesting project in which I became heavily involved was the South Pacific Biodiversity Conservation Programme funded by the Global Environment Facility, helping 14 Pacific Island countries to develop locally managed protected areas. In 1993, I was invited to prepare a keystone paper on land-based pollution and integrated coastal management (Dahl 1993) for a special issue of *Marine Policy* on UNCED's marine agenda and the challenges of its implementation. With the rapid expansion of satellite remote sensing, there was a growing need to improve the coherence of many national satellite programmes and promote the scientific use and assessment of the resulting imagery. Thus, I helped lead the development of integrated global observing strategies, including for coral reefs, leading eventually to the formation of the intergovernmental Group on Earth Observation (GEO). As a result, I also became a member of the Steering Committee of the Global Ocean Observing System (GOOS), a

participant in the Sponsors Group for the First Integrated Global Observing Strategy (IGOS) Partners Meeting, and a participant in the GESAMP Working Group on Marine Environmental Assessments.

Finally, in career terms, in November 2000, I was named Director of a new UNEP Coral Reef Unit, a post I occupied until my retirement in 2002. This involved designing and launching an International Coral Reef Action Network (ICRAN) linking coral reef scientists, NGOs and interested governments. This led to participation in the International Coral Reef Initiative (ICRI) Coordination and Planning Committee (CPC) meeting in Noumea, New Caledonia. Meanwhile, I was able to attend the 7<sup>th</sup>, 8<sup>th</sup> and 9<sup>th</sup> International Coral Reef Symposia, and participate in further committees and programmes. The ICRAN, ICRI Regional Workshop, and IGOS meetings continued in Cancun, Mexico, while NCORE held a Workshop on the Future of Decision-support for Coral Reef Management in Miami, Florida. Some of the outcomes I wrote up as “IGOS Coral Reef Theme” in *Reef Encounter* in 2002 (Dahl 2002a).

The Rio Earth Summit was followed ten years later, in Johannesburg, South Africa, by another highly significant international meeting - the 2002 **World Summit on Sustainable Development**. I represented ICRAN as a type-two partnership for coral reefs, featuring collaboration between the UN and the scientific community. A major event in 2005 was the participation of organisations at the Mauritius International Meeting on further implementation of the Programme of Action for Small Island Developing States, where

I chaired a side event for ICRI. There I participated in the presentation of the South Pacific Applied Geoscience Commission (SOPAC) Environmental Vulnerability Index, a methodology that demonstrated the particular vulnerability of small islands. In 2008, I attended the International Coral Reef Symposium in Fort Lauderdale, Florida, for what was effectively my last opportunity to be directly involved with coral reefs. The rest of my career has been concerned with sustainability indicators, small islands, climate change, environmental assessment, values-based indicators, and measurements of wellbeing. Most recently, I have focussed on global environmental governance, since in the absence of strong governance, climate change is accelerating, coral reef ecosystems are collapsing, and biodiversity faces an existential crisis.

Looking back on all these coral reef activities over almost forty years, I was fortunate to be able to contribute to bridging basic science with government policy, and with action in the water. Too often academic research is published in scientific journals or technical reports to which government policymakers have little access. Research findings of global significance may seem very distant to those dealing with practical problems on their local reefs. There is a vital need for those who know the science and participate in research to also learn how to communicate the key findings of their work to governments and administrators in a language the latter can understand. At the same time, international conventions and agreements need to be drafted to be cohesive with and responsive to scientific realities. The urgency of actions to save what we still can of coral reef ecosystems needs to be communicated to leaders and the general public, for there is a wide gap between government agreements to implement a range of actions and the practical implementation of those actions. Coral reef specialists have an important role in demonstrating that actions can produce visible results for the common good.

Reefs now are nothing like those I knew in the 1970s. But they are examples of complex systems that demonstrate how close cooperation, symbioses and integration of many diverse components and functions can achieve high productivity and resilience in a circular economy, including a place and a constructive role for every organism, however seemingly insignificant. This really is a model for human society in our globalised world. In my life I have tried to build on these lessons, going from direct reef studies through motivating national action, up the causal chain of threats to reefs, eventually working to reform the United Nations system, in the hope of securing an effective mandate for global legislation that can bring the Planet Earth back within acceptable system boundaries. Hopefully this will enable both coral reef survival and regeneration on the one hand, and sustainable human wellbeing on the other. Perhaps my efforts will inspire others to rise to the occasion in this time of coral reef crisis.

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