Stone fish weirs of Yap

Bob Johannes visited Yap when he was contemplating the work that lead to *Words of the Lagoon*. On one of his visits we spent a wonderful afternoon diving after manta shrimp — as much for the joy of free diving, as to collect the shrimp. Later my Yapese father-in-law, Blas Lubuw, explained how we could have saved all that energy and caught the shrimp by placing a half coconut shell over their hole with a hinged mantis claw tied to a stick extending through the hole of the shell. The shrimp would swim up out of its hole toward the light coming through the hole of the coconut shell, slide by the hinged claw and then become impaled on the claw when it retracted back. A wiggling stick indicated a hooked shrimp. Of such marvellous increments was our appreciation of traditional knowledge built. Through the years, Bob was to come to our aid with information and advice on addressing environmental impacts that threatened marine resources, and along with them an island heritage. His enthusiasm helped maintain our efforts. Here we share an abstract of an ongoing project that began about the time the co-author of this paper was born and Bob and Chris had moved to Palau. We spoke of stone fish weirs as there were only a few in Palau but many in Yap — so many, that we wondered about their use and management. In time Lubuw, Martin Faimau and I set out to map these weirs as a step toward deciphering the knowledge left written in them.

Located in the western Caroline Islands of Micronesia, the high islands of Yap are best known as the land of stone money. There are other remarkable structures made of stone as well. As one flies into the state's main islands, large stone arrows, generally pointing away from the island, can be seen in the lagoon. So prominent are these large stone fish weirs, called *ach*, that some 52 are mapped on the 1983 USGS map of Yap. Through field and aerial surveys we have now found and mapped at least another 752. *Ach* are an example of Yapese nature-integrated technology.

Rather than chase fish around each time they go fishing, Yapese of the past built *ach* to make use of tides and fish behavior to concentrate fish. These large stone weirs make use of the properties of both land and coral rocks. With foundation stones placed so that wave action tends to wedge them together, the weirs have remained in place through many typhoons. Indeed, an *ach* shown on a map made in 1885 is still in place. The large weirs were built in three main configurations: arrow-shaped, V-shaped and zig-zag; with variations on these patterns adapted to different purposes and site conditions.

In the basic arrow-shaped *ach* (Fig. 1) the long central shaft directs fish toward the main holding compartment at the tip of the arrow. Here the fish swim about freely, but as the tide recedes, the configuration of the weir and currents direct them toward smaller chambers where they may be trapped. Some *ach* have stone chambers called *lieb* to hold fish. In others it is necessary to install a bamboo trap and holding box, *yinup ko ach*, to retain the fish when the tide rises over the walls of the *ach*. The fish caught in *ach* are captured gently, without a struggle, ensuring their good quality and taste. When not in use, gaps in the rock walls are left open allowing fish to swim right on through the *ach*.

Some weirs, especially those located on sand and reef flats along routes taken by fish are built without the central shaft. The V-shaped body of the weirs (Fig. 2) are often extended by a single rock wall. In some weirs, the central compartment is the most prominent part; in others, the extended walls lead to a smaller, triangle-shaped holding compartment.

On some reef flats there are a series of single-walled, V-shaped weirs alternately arranged so they form zig-zag bands similar in appearance to the *ume iki* of Hawaii (Farber 1997). These weirs lack the central compartment and serve like funnels to concentrate fish where they are caught with hand nets at the apex of weirs that point toward land on the incoming tide and at the apex of weirs pointing toward the reef on the outgoing tide.

Of the over 800 weirs we have mapped (counting each V with or without elaborations, as a separate weir), about 67 per cent are basically arrow-shaped. Some 33 per cent are basically V-shaped; with about 42 per cent of these consisting of sets of alternating V-shaped formations on the reef flat. There are many variations on the basic configurations of weirs, with some *ach* having long extensions on the central holding compartments, and some having intricate configurations of the chambers within the main compartment. Figure 2 shows *ach* with the central shaft placed at such an obtuse angle that they are essentially V-shaped. Some *ach* are linked by extended arms, and at times leaf sweeps made of palm fronds twisted about a rope may be used to herd fish toward *ach* to obtain large catches for especially big community events. Most weirs point away from the island or towards a blue hole or channel; however, some in the outer lagoon point toward the island, and a few are parallel to shore. Some areas of Yap's lagoon have greater concentrations of *ach* than others, with the number of *ach* per quadrant of the USGS map ranging

Figure 1.
An arrow-shaped ach with an extended arm, series of compartments and a holding chamber, *lieb*.

Figure 2.
V-shaped weirs on the reef flat. There are submerged weirs between and to the lower left of the two prominent weirs.

from 0 to 24. A number of *ach* are paired and a number are composite, with two to four sets of V-shaped compartments on a single shaft. Many of the weirs we have mapped are quite eroded and some of these appear like shadows of nearby *ach*, suggesting that they were built at different times, or were relocated. Twenty-eight percent of weirs are located in areas exposed at low tide, about 20 per cent are located along the edges of Yap's "blue holes", to catch fish retreating to these depressions within the lagoon at low tide. Another 20 per cent are associated with a channel and about 28% are located on sand flats or the reef flat.

Most *ach* must have been built at a time when Yap's population was very dense as they represent a considerable investment of human energy, although once built, they conserve energy. Yap's population declined from pre-contact peaks estimated at 3367 people/km^2 to a low of about 27 people/km^2 at the end of the Japanese administration (calculations of people/km^2 based on Lingenfelter 1975). Maintenance of *ach* declined during this period and today with the advent and widespread use of monofilament nets, only a few *ach* are actively maintained. Now with a rapidly rising population, increasing environmental pressures and both subsistence and commercial exploitation, improved stewardship of fisheries resources is greatly needed. The stone fish weirs of Yap provide opportunity for a synergy of modern science with a traditional technology and system of resource management. *Ach* apply past knowledge of fish behavior, tidal patterns and marine engineering to concentrate fish for capture. When not in use, the weirs do not entrap fish. The great number, variety and distribution of *ach* thus provides a potential tool for monitoring fish stocks and aggregations. Inasmuch as *ach* are associated with specific estates, with their use governed by the head of the estate, they may also provide a regulated venue for mariculture and perhaps even ecotourism activities, thus diversifying and enhancing fisheries in neotraditional ways.

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Johannes as a pioneer

Bob Johannes was a real pioneer because he was true to himself. The paths he took were his own judgements of what was critical or what was the important key issue at that time. His pioneering work was exceptionally original and influential because he followed his own insight into truly important processes and was not constrained by the mainstream paradigms and by the perspectives of his administrators. It is compelling for most scientists to follow the mainstream flow of technological advances such as mapping of reefs from satellites that are circling the globe, and mapping of genetic populations by microsatellites in the genetic chemistry. But Bob was able to recognize the value of the knowledge of peoples of other perspectives and he observed that Pacific Islanders knew their coral reef fishes far better than scientists, and that their traditional management practices were more effective. He was able to listen to local fishermen, placing their knowledge as complementary to science, rather than patronizing them with his technical training. It really took an open mind to be the first to listen to uneducated people as peers, but he was able to recognize that many of their ideas were correct.

Bob Johannes was also the first to recognize the importance of having the general public be aware of implications of new findings in coral reef ecology. He produced a movie on Hawaiian coral reef degradation, *Cloud Over a Coral Reef*, for the general public in the hopes that some action would be taken to correct the problem. Some of his colleagues gave him flack for this. At the time, they felt that scientists should remain solely with basic science and communicating with the public was for someone else to do, as may still be the case in some Asian nations. His dataless adaptive management will be the most effective approach to the complex and unpredictable interactions and replenishment of coral reef resources. This radically different approach was risky for a career, but history will show that his ideas will ultimately be among the most effective and influential, hopefully in turning society around and guiding us to effectively manage resources.

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