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TECHNOLOGICAL INNOVATIONS AND MULTIDISCIPLINARY APPROACHES FOR SUSTAINABLE MARICULTURE DEVELOPMENT FOR PACIFIC INSULAR SETTINGS

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ABSTRACT

In an attempt to delineate the sociocultural consequences of marine resource development in remote insular Pacific settings, the potential for mariculture is explored using a multidisciplinary approach within a technological innovation model framework. Sponge mariculture acts as a proxy for the 'technological innovation' introduced to the environment and culture of the outer atolls of Yap State in the Federated States of Micronesia. A number of data sources review the biological, technical, and economic viability of sponge farming in the remote outer atoll setting of Yap. The social and cultural situation on Yap proper and the outer atolls, with special focus on Ulithi atoll, are presented using contemporary information and ethnography from the 1950s through the 1980s. These information sources (social/cultural and economic/technical) are combined in an innovation model used by social scientists to focus discussions of variables related to intermediate technology programs. The model qualitatively reviews five attributes of change (in the development context): **complexity, compatibility, advantage, trialability**, and **observability**. Three methods of introduction of the innovation are also explored (indigenous, governmental, and entrepreneurial) employing a model on marine tenure systems to provide precision in the discussion of this fundamental subattribute.

Results suggest actual farm establishment appears to fall within current cultural norms; however, gender roles may be modified, with actual farm maintenance more culturally suited for females than males. Moreover, how traditional leaders view sponges as an exploitable resource may bear heavily on the potential for outside investment and access to requisite technology. Despite apparent abundance of seed stock and a marine tenure system conducive to exclusive use, several social factors may preclude private or indigenous investment. Mariculture extension and support resources are needed during initial grow-out to ensure success, but complete government subsidization appears to be a suboptimal option. The social model employed here, while in need of refinement, can be of use for a variety of economic development scenarios.

INTRODUCTION

Typically marine resource development activities in tropical insular Pacific areas focus on the biological and economic viability of a particular technological application. In this vein development project appraisals may ignore or underestimate an important determinant in the application of innovations or technologies--the sociocultural consequences. Yet, as Pollnac (1978) indicates:
"...it is essential that the proposed technology be congruent with the total environment, including the sociocultural context within which it will operate".

A number of economic development activities appear technically suited for isolated marine environments of the tropical Pacific, with mariculture representing one possible option. However, to date mariculture activities have not yet proven universally successful in many locations throughout the tropical insular Pacific (Munro 1994). Relevant examples of concerted efforts with minimal success reported to date include seaweed culture (Federated States of Micronesia (FSM) , Fiji, Kiribati), giant clam farming (the Marshalls, Tonga, Fiji, Solomon Islands), and finfish culture (mullet in Kiribati, tilapia in Tonga and Fiji, and rabbitfish in the FSM). Relatively few activities have demonstrated long-term technical, much less economic, viability after government supports were extracted leading several analysts to question mariculture itself as a tenable development option (c.f. APTA 1990, Murphy 1980, Uwate 1989, Uwate and Kunatuba 1984). And even the one clear exception to this general trend, black lipped pearl oysters culture has come at considerable social upheaval in French Polynesia and the Cook Islands (Rapaport 1993, Roundtree 1993, Dashwood 1994). While a comprehensive review of the previous mariculture failures in the insular Pacific would be beneficial, it is beyond the scope of my focus here. Rather, an alternative approach is taken by reviewing attributes related to the introduction of a new technology into a completely alien setting. By examining the sociocultural context of the introduction of a mariculture activity into traditional Micronesian cultures, hypothesis are developed on the greater prospects for marine resource economic development.

As a framework for analysis I review social and ethnographic information to determine the sociocultural factors potentially influencing the success of the introduction of a new technology into traditional Pacific societies. The outer atolls of Yap State, in the FSM, represent some of the least externally influenced settings in Micronesia and provide the setting for the analysis. Currently there is considerable out-migration from the outer atolls to the urban center in Yap and other areas of the FSM (FSM 1991). To stem this outflow, planners allude to the prospects of creating economic opportunities in rural areas (the outer atolls) to provide an incentive to remain in traditional locations.

METHOD/MODELS

The analysis is broken into two major sections, with a melding of empirical data from both sections providing the basis for discussion and conclusions on the prognosis of mariculture potential in the outer atolls of the FSM. The first section describes factors relating to sponge supply and demand, through time and more recently in the Pacific. This analysis provides technological and economic data from a variety of published and unpublished sources including a summary of the feasibility of expansion of development activities currently centered in Pohnpei State to the outer atolls of Yap State. Following this discussion information on the geographic, political, cultural and institutional situation in Yap State, focusing on Yap proper and the outer atolls is presented. Ethnographic data is provided on Ulithi atoll and to a lesser extent atolls farther east. This information reveals the interlinking yet, contrasting traditional cultural settings between Yap proper and the outer atolls. Included in this discussion are matters relating to marine tenure, in which Sudo's (1984) classification system is employed for precise delineation. Marine resource use is explored in an attempt to hypothesize how sponges, which have not been traditionally exploited in the outer atolls, may fit into the current cultural and economic setting.

The cultural descriptions are based on ethnographies compiled between the 1950s and the 1980s. It is clear, despite their relative isolation, that these atolls are currently undergoing significant change. Therefore, the description provided here is written in an ethnographic present attempting to approximate precontact cultures. Data have been collected through interviews and field observations. A number of visits were made to Pohnpei and Yap State during the previous five years, including a trip to Ulithi in September, 1994. Additionally, I have acted as program officer on three projects specifically focused on sponge mariculture, as well as dozens of other marine resource development projects in Micronesia.

In an attempt to build an analytic framework demonstrating that technology transfer consists of several essential and interrelated ingredients, Pollnac (1978) reviews the sociocultural factors influencing the success of intermediate food technology programs using five attributes associated with innovation as proposed by Rogers and Shoemaker (1971). Pollnac states that the innovation must be compatible with the target environment; the economy and the idea must be communicated/introduced appropriately. Moreover, the target population must perceive the value of the new technology within the existing belief, value, attitude, and status relationships of the target group. These primary criteria typically have significant influence leading to the adoption or outright rejection of an idea, technology, or innovation. Successful introduction occurs only when the innovation becomes institutionalized, thereby becoming part of the sociocultural system. The five attributes are identified as the following:

Complexity--this attribute is a subjective judgment but relates to the technological development of a particular society, culture, or setting. Given that the innovation is focused at a target group, a determination must be made on the target group's ability to assimilate the information provided. This decision would be based on several criteria, such as parallels to current experiences, levels of training necessary to actuate it, and the availability of individuals or methods for technological transfer.
Compatibility--this attribute is of crucial importance and relates to how the innovation may contribute or detract from current cultural practices. This involves how the innovation complements or interrupts current practices, in what way and by whom. For example, what are gender roles in the focus group? The innovation must be evaluated as to its social or political ramifications. The innovation must be compatible with existing aesthetics, religions, status, and other cultural attributes. Ideally the innovation will be introduced in a manner such that conflicts are minimized.
Advantage--typically viewed by developmentalists as the financial return, this attribute has far greater implications, with no universal definition especially for non-market oriented societies. Advantage is displayed in terms of benefit for the target group. This may be manifested as an advantage over an existing technology or as an expansion of an existing activity (e.g., technological advantages leading to increased leisure time). Caution must be advised in that advantage tends to focus on groups or individuals, and what is perceived as beneficial to one may not be similarly perceived by others. The disruption of current traditional relationships and behaviors must be addressed as to who benefits and who loses.
Trialability--relates to indigenous or endogenous reflections relating to willingness to attempt risky activities. Typically, traditional groups are considered risk averse in that innovations must demonstrate significant advantages over existing practices. Subsistence level producers typically do not undertake risky or innovative activities because of lack of reserve capital or resources. If the cost of innovation is such that few can afford it, or benefits are questionable, the society may actually fight against the innovation. Typically individuals with socioeconomic power and access to information are most willing to engage in innovative activities. Questions relating to social stratification and access to resources bear heavily on this attribute.
Observability--this relates to perception of success or failure. Innovations most likely to succeed are those in which a quantitative appraisal of advantage is made by casual observation.
Rates of adoption may also be attributed to observability.

In addition to the model used for innovation, a discussion of the organization of marine tenure systems in Micronesia is provided. The concept of marine tenure refers to a set of rights and duties that arise in relation to real property. It is the system by which some person or social group utilizes sea areas, controls the extent and degree of exploitation of their waters and by that protects areas against over exploitation (Sudo 1984). Sudo (1984) proposes the following basic system whereby Micronesian societies are grouped into four major categories or types, progressing from less to more subdivided or segmented lagoon or reef areas:

Type I: Inshore waters are considered common property of all the islands or villages. Fishing rights are controlled by a central authority (Chief or council). Examples may be found in Palau and Pohnpei.

Type II: Specified sections of the inshore waters are owned by a particular kin group (clan or lineage). There are also open access areas (e.g., Marshall Islands).

Type III: Societies in which lagoon waters are divided into subsections "owned" by a particular kin group (e.g., Outer islands of Chuuk, Mortlocks)

Type IV: Reef or lagoon waters are divided into small tracks and owned by a family group.

The type of tenure system employed has significant implications on activities involving use of marine resources; for mariculture these systems are especially salient. A considerable body of empirical and theoretical economic data indicate tenure or access mechanisms must be established and secure before economic activity (investment) can begin and be sustained over the long-term. Finally, this study represents a qualitative analysis. Ideally one should address the above attributes quantitatively, by not only delineating the various factors but by including some measure of "degree." To adequately broach this question involves investigation into what extent cultures vary in terms of technological adaptability and the extent that any methodology can quantitatively measure these attributes would be required. The consideration of degree is left to future studies.

SPONGE FISHERY AND MARICULTURE DEVELOPMENT

Sponges were reported harvested first from the sea in early Greek literature. Commercial harvest eventually spread to the Mediterranean, Caribbean, and the Pacific Ocean (Moore 1910). While there are more than 5,000 species of sponge worldwide, only about 15 species have human and commercial applications (Josupiet 1990, 1991). A commercial sponge is the macerated and dried skeleton of a natural sponge with the main commercial attribute coming from its substantial internal surface. Sponges absorb 20-25 times their weight and have been used for thousands of years by humans for personal and household applications (Moore 1910, Josupiet 1991, Wilkinson 1988).

Sponge fishing initially took place in Greece and Tunisia as long ago as 5,000 years. During the first part of the 19th century sponge dive fisheries began in earnest in Libya, Tunisia, Greece, and Italy. By the end of the last century exploitation expanded considerably, with fisheries developing in Florida, Cuba, and other tropical Caribbean islands. Worldwide natural sponge production reached a peak in the 1930s, but almost all fishing occurred on an unsustainable basis. For example, Cuban sponge production rose to 1,000 t/year (or 13,000,000 animals) in the 1930s but dropped to only 0.2 t by 1947 (Josupiet 1991). By the 1950s, with the introduction of synthetic materials, catastrophic diseases in the Caribbean and Mediterranean, and a dramatic increase in relative price (due to reduced supply), natural sponge utilization shifted from commercial applications to exclusive use as a bathing or household item. In the 1980s, worldwide natural sponge production oscillated between 160 and 270 t (Josupiet 1990, 1991, Shang 1991). Tunisia accounted for approximately half the contemporary global supplies (100 t/yr), but production decreased due to disease outbreaks during the summer of 1986. Greece, the historic producer of natural sponge has seen local grounds depleted, while exploitation off Egypt, Libya, and Tunisia ceased due to access regulation. Josupiet (1991:27) concludes that:

"the [current] boom of natural products increased the usage of marine sponges, especially as bath sponges. Additionally, large sponges are sold at prices out of reach of the consumer and that overpricing will lead to consumer resistance despite demand. Importers and processors are seeking alternate supplies...."

With local and regional depletions of natural stocks, several early attempts were reported on sponge mariculture. The first mariculture attempts were made in Florida in 1879 (Josupiet 1991), but extensive tests were conducted in the 1930's in the Caribbean (Bahamas, (Storr 1964), Belize (Smith 1941, Stevely and Sweat 1994) and Florida (Moore 1910 and Shubow 1969)). During 1938-39 a sponge disease swept through the Caribbean and Gulf of Mexico and while reducing wild commercial harvests, also apparently affected mariculture efforts (Stevely and Sweat 1994). During approximately the same period (1930s), sponge cultivation experiments were being independently conducted by the Japanese in Micronesia. More recently, Verdenal and Verdenal (1987) evaluated two sponge culture strategies based on French factor inputs and report positive return on investment (over a 10-year period) and break-even income at between 4-5 years. However, no information is available on commercial mariculture developments resulting from their analyses.

Prior to World War II, the Japanese experimented with culturing sponges around the high islands of Pohnpei, Chuuk, Palau and the outer atolls of the Marshall Islands (Smith 1947 a, b). While Japanese studies on Micronesian sponge culture activities reportedly exist (H. Tanaka pers. comm.) most westerners refer to a 1948 report by A. R. Cahn. Cahn traveled throughout Micronesia after World War II as a scientific consultant to the Fisheries Division of the Natural Resources Section based at General Headquarters, Supreme Commander for the Allied Powers in Tokyo, Japan. He reports sponge culture experiments were initiated in 1927 in Pohnpei lagoon and culminated in successful cultivation in the Marshall Islands. The Japanese were interested in sponges for cosmetic and surgical use. Pohnpei lagoon was reportedly found to be "unfavorable for sponge culture"--ironic in that it now has become the epicenter for current sponge mariculture activities in the Pacific, with experiments also conducted in Chuuk lagoon and in Palau between 1930-35. However, the focus of Japanese attention was on Ailinglaplap Atoll in the Marshall Islands with activities reportedly initiating in June 1940 and ending in October 1943. On Ailinglaplap the Japanese employed four basic growout techniques, of which three were patented and involved the use of vegetative cuttings suspended off the bottom of the lagoon floor. The same basic technology was later updated with modern materials and provides the basis for current developments.

In approximately 1984, a U.S. biologist initiated experiments culturing commercial sponges within Pohnpei lagoon in the FSM. This individual was previously involved in a number of mariculture attempts (*Eucheuma sp.* , *Tridacna spp.* *Trochus* and Siganidae) and felt limited from various perspectives: social and cultural, technical, and economic (Croft pers. comm. 1993). (See Shang 1989 and APTA 1990 for a more rigorous evaluation of various mariculture species in FSM.) He felt western agriculture, and in turn mariculture, with emphases on intensive maintenance and oversight requirements, conflicted with traditional Micronesian culture and sought alternatives requiring minimal labor inputs. Sponge culture provided a possible alternative, with several attributes suggesting further investigation (high value to weight ratio, low maintenance, easy/low technology required for grow-out and processing).

By 1985, private cultivation experiments were well under way in Pohnpei lagoon using a species of sponge tentatively identified as the wooly sponge, *Spongia officinalis* (Wilkinson 1989). Due to the relatively close-knit community of biologists and resource managers, these private activities became incorporated into Pohnpei State and FSM Marine Resources Department official work plans. Between the private activities of the biologist and public sector support for research and training, efforts concentrated on expanding available seed stock while conducting basic biological experiments. By October 1988, Wilkinson (1989) reports that there were "approximately 3,000 pieces of transplanted sponge of apparently high commercial quality in several locations in the lagoon." A survey of wild commercial sponge beds in Pohnpei lagoon was also completed (Croft 1990). During this period several studies were completed to determine global sponge supply and demand patterns (i.e., Josupiet 1990) and assessments of sponge economic viability (Shang 1989, 1991). By mid 1989, sponge culture activities

received support from the U.S. Department of Agricultures, Center for Tropical and Subtropical Agriculture (which has continued until the present (1995), focusing on determination of sponge growth and survival rates (monthly growth rates were reported between 3 and 15%). Through international and U.S. development assistance a number of additional private farms were set up in Pohnpei lagoon of which at least one had over 5,600 sponges under cultivation (Croft 1993). As of late 1994, it is estimated approximately 30,000 sponges were under cultivation. Large-scale marketing is scheduled to begin, initially focusing on tourist and curio markets in the FSM and Guam (Croft and Brown 1994). Prospects for industry development at this time appear promising. Other Pacific Island States (Kiribati and Fiji) are investigating the potential for local development.

The basic determinants of optimal sponge farm siting are not precisely known but appear to include protected waters (away from large waves or tidal surges) proximal to well-mixed or flushed areas. Sponge farms entail arrays, typically placed inside protected portions of the lagoon using coral out croppings as natural anchors from which sponge cuttings are suspended. Coral heads, submerged in at least 2 to 3 m of water are used to anchor 4-8 mm diameter polypropylene lines, with a parallel spacing of 12 to 18 m apart (Fig.1). Nylon lines (60-70 kg breaking strength) are strung between the polypropylene line at approximately 75 to 90 cm intervals. Sponge cuttings are hung from these lines using 20-kg test nylon lines. Individual sponge cuttings are spaced 40 to 50 cm apart on the 60-kg line using a loop attachment (Fig.1) and take approximately two plus years to reach commercial size.

Sponge seedlings are harvested from wild sponge beds by cutting off the top two-thirds of the animal with a sharp knife. Croft (1992) reports that the wild sponge quickly recover after cropping. Nonetheless, efforts to ensure conservation of these important wild stocks are critical for industry development, and efforts have been focused on expanding existing seed stock. Once the hanging/floating array is completed, the following procedure, as described by Croft (1992:29), is used to plant sponges:

(1) A parent sponge (obtained from wild stock or previously grown material) is cut into smaller "cuttings" of at least 200 g each (or the size of a tennis ball). This must be done while in the water, keeping the parent sponge and cuttings submerged at all times. The cutting knife must be sharp so as not to tear the sponge. Part of the dark or black skin on the surface of the sponge should be included in all cuttings.

(2) A short (40 cm long) segment of 20-kg test nylon line is inserted through the cutting. This can be done in several ways: a small knife can be used to poke a small hole in the cutting, or a needle can be used to pass the line through the sponge, or a stiff piece of wire will work--sharpness is the main determinant of success.

(3) The ends of the 20-kg line are tied together into a loop. This loop is used to suspend the cutting from the 70-kg line shown in Figure 1.

(4) The final step involves looping the 20-kg line over the 70-kg line as shown in Figure 1.

Croft reports that a total of about 3 weeks (5 days a week, 3-4 hours a day) is required to train motivated individuals in sponge planting activities. Also mentioned were problems related to trainees dropping out of the program prior to completion, which he suggests is a result of lack of pay (during training) and the difficulty of trainees envisioning success (Croft 1993). Additionally, while controlled experiments showed planting survival in excess of 93%, demonstration farms in Pohnpei lagoon managed by local trainees suggest lower survival rates of 70-75% (Croft 1992) and may be more realistic for commercial operations.

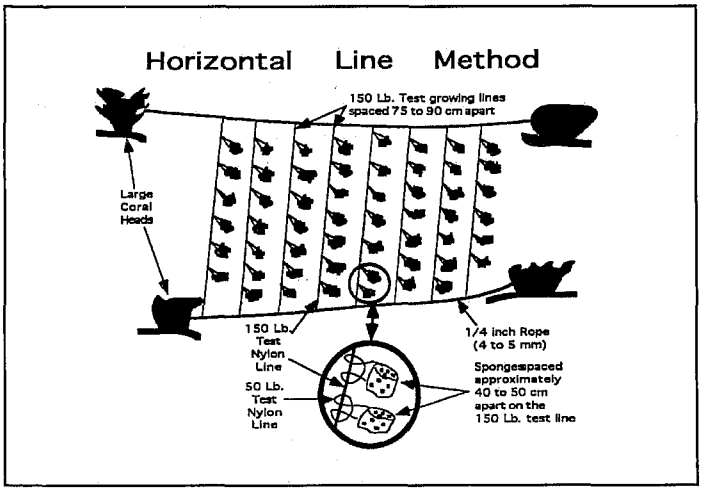

Figure 1. Diagrammatic of method currently used for sponge mariculture in Pohnpei, FSM (adapted from Croft 1993).

Processing of the matured sponge is relatively straightforward: sponges are harvested, normally after 2-2½ years, and placed in plastic mesh (1 cm sq) containers, approximately 1 meter square and left to "rot" for approximately 4 to 6 weeks. The important factor here is that all black epithelial material (skin) is flushed free from the sponge. Sponges are then removed from the lagoon, rinsed thoroughly with fresh water and washed in a household washing machine, after which they are sun dried. After some minor trimming the sponges are ready for sale. For areas lacking electricity and abundant sources of fresh water, processing can be abridged to include just the lagoon rotting and sun drying, with final processing at an urban center. However, final pricing will be adjusted according to processing method (Croft per. comm. 1993).

Croft (1993:31) emphasizes the need for extension and training services to demonstrate requisite farming techniques, as well as providing support to farmers during the grow-out stage "to maintain the farmers' enthusiasm and effort." He warns that during the 2-year grow-out period a "farmer may lose interest, as it will seem to him that not much is happening." And he recommends extension services be provided by State (governmental) aquacultural extension agents, in a similar manner to those found in the United States.

A number of reports and studies were completed on the economics of the development of sponge culture in the FSM (Shang 1989, 1991, Croft 1989, Wilkinson 1989, APTA 1990, Stevely 1989, Stevely and Adams 1993). All economic analyses use similar, but continually refined, parameters based on current activities in Pohnpei lagoon to estimate profitability. The data for these pro forma evaluations are therefore limited and should be viewed with caution. Currently there is no purely commercial sponge mariculture in Pohnpei and all development activities have been significantly subsidized by the public sector (predominantly through bilateral international aid). It is with this significant caveat that the following analysis is presented.

All economic studies report positive return on investment, over and above economic inputs. Stevely and Adams (1993) present the most comprehensive analysis, conducting sensitivity analysis on a variety of parameters, with most scenarios showing positive returns. Using a prototypical 1-acre farm based in Pohnpei lagoon, with a third of an acre being put into production each year for 3 years, sales are assumed to begin in year 4. Farm grow-out design is modeled after that developed by Croft (1992) and assumed to be the property of a single family or clan, with no additional need for non-familial labor sources. Planting is assumed to be 4,600 seedlings per year (383 pieces per month), with harvest of 6-inch sponges after a 3 year grow-out period. Survival of planted sponges is assumed to be 90%, with 35% of the initially planted sponges going to reseeding for restocking. Eighty percent of the sponges harvested are of marketable size and shape; therefore, 52% or 2,400 of the original sponge seedlings planted are expected to be suitable for marketing. It is assumed that no scuba diving is used after the farm is initially set up and there are no losses due to poaching or pilferage. Moreover, Stevely and Adams assume that an aquaculture extension program will provide initial seed cuttings and other startup services free. Their analysis provides a breakdown of estimated labor and activities (Table 1) and returns based on an operation purchasing and using a small skiff to aid in culture operations. The investment horizon is estimated at 10 years, with capital purchased at 12% and an opportunity wage rate of $1.25/hour. Local taxes and fees are not included, and a straight line depreciation is used for all capital assets, with zero salvage values. Finally, no marketing costs are incurred, and no costs are associated with lagoon or land ownership or leasing.

Results indicate that to set up a 1-acre farm requires an investment of $650 in supplies, excluding the boat purchase (which is not a critical item if the farms are properly sited and pilferage is not a problem) and 64 hours of labor each month. This farm should generate a positive net return of $1,744 or $2.30 per hour (Table 2) if each sponge is sold for $1.00. When foregone labor wages are excluded (@ $1.25/hour) returns remain positive ($784/year). The estimated input (cost) per sponge is $0.27, and a 43% survival rate is required to cover costs of production (Table 2). Market price to the farmer is expected to vary depending on target markets and production. Fundamental supply and demand relationships are assumed to occur once local tourist and curio markets on Pohnpei and Guam are saturated. Stevely and Adam (1993) estimate that to enter the international market sponge production must be on the order of 200,000-400,000 pieces per year at a price of approximately $1.00 per sponge. However, in the short-term initial producers may see supernormal profits with prices between $1.50 and $2.75/sponge. Sensitivity analysis reveals the model to be robust in terms of capital costs and farm size but sensitive to market price and survival rates. The authors recommend that the opportunity costs of labor should be considered before entry into sponge mariculture and allude to the need for business acumen to ensure success.

While not evaluating more remote settings, it appears reasonable to assume that sponge mariculture could provide positive return on investment. However, this comes with several additional caveats: the lack of proven, readily available seed stock, unknown transportation and processing costs and the undetermined productivity of labor. What one can assume is that the return will be less than those projected for Pohnpei. These anticipated increased costs may be counter balanced with the reduced opportunity cost of labor in outer atoll settings. Pending further analysis, overall the economics as presented using the Pohnpei case appear reasonable, allowing one to assume *pro forma* that positive return on investment can be expected from sponge mariculture in remote outer atoll settings.

With the relative technological success and apparent economic viability of sponge culture in Pohnpei, several government agencies (both within the FSM and the U.S.) sought to investigate expanding activities, specifically focusing on the outer atolls of the FSM. In 1990, an assessment was conducted by the Yap Fishing Authority, in cooperation with the Yap Marine Resources Management Division to determine the occurrence and relative abundance of commercially valuable sponges in the

outer atolls of Yap State. Due to the feeding patterns of the sponge and the unknown residual fauna, and pathogens, etc. it was felt that transfers between lagoons should not be encouraged.

Scuba surveys were undertaken in an attempt to locate the *Spongia officinalis* in eight outer islands or atolls (Bridgeland 1992). During 730 dive hours between 3-30 meters (number of scuba dives = 45, other dives done via snorkel), *S. officinalis* were found at Ulithi, Elato, and Faraulap lagoons. While a substantial number of dives (n = 9) yielded no sponges at all or no *S. officinalis* (n = 7), six dives yielded 10 or more. Bridgeland estimates *S. officinalis* standing stocks at 300,000 individuals at Ulithi, 6,000 at Elato and 1,700 at Faraulap, while noting their particularly patchy distribution. During one dive at Ulithi atoll a total of 62 *S. officinalis* were recorded. This promoted the conclusion "only in Ulithi is it likely that the wild populations are large enough to support a large scale aquaculture operation."

Bridgeland further recommended, among other things, that small-scale pilot farms, "having private/local investment" be encouraged, and each island community maintain their farm along with the establishment of a system of purchasing, with the Yap State government acting as the intermediary for sponge purchase and marketing. Bridgeland discounts the possibility of

Table 1. Labor required for startup and maintenance of small-scale sponge farm as proposed by Stevely and Adams 1993.

Labor Activities	Requirements Per Person[1]	Hours Per Day[2]	Total Hours Per Month[3]
Year 1-3			
- Planing Labor (cutting & stringing sponges)	2 days/mo.	4	16
- Maintenance Labor (site inspection. line & boat repair, sponge replacement, etc.)	1 day/mo.	3	6
TOTAL			22
Years 4 and beyond			
- Planting Labor	2 days/mo.	4	16
- Maintenance Labor	2 days/mo.	3	12
- Harvest Labor	1 day/mo.	6	12
- Rotting, Cleaning, and Storing Labor	2 days/mo.	4	16
- Marketing	1 day/mo.	4	8
TOTAL			64

[1]a Requirement given in "days/mo" refers to the number of on-site visits required per month. "2 days/mo" indicates that the owner needs to be on site engaged in the respective activity at least 2 days in a given month.
[2]Refers to the minimum number of hours required per on-site visit per person to accomplish the activity.
[3]Indicates the total number of hours (minimum) required on-site per month for a two-member team to accomplish the activity

local outer atoll residents having sufficient capital to invest in sponge farming and emphasizes the need for government-run demonstration farms. Therefore, government support and intervention are recommended. Finally, since sponges are a newly identified resource, he claims that ownership is unestablished and the issue of access to important broodstock should be put to the Council of *Tamol* (described later).

Table 2. Breakdown of estimated costs and potential returns for a 1-acre farm established in Pohnpei lagoon, FSM (adapted from Stevely and Adams 1993).

- Initial Investment (without purchasing a boat)	$650
- Number of Sponges Planted: per month per year	 383 4,600
- Acres Planted per Year	1/3
- Number of Sponges Sold per year	 2,400
- Average Annual Production Costs	$500
- Hours Required: per month per year	 64 768
- Annual Net Returns: to capital, labor, and risk to capital and risk	 $1,744 $784
- Returns per Hour of Labor	$2.30
- Cost per Sponge	$0.273
- Break-even Survival Rate	42.8%

YAP - FEDERATED STATES OF MICRONESIA

Yap State is located within the Western Caroline Islands between latitudes 7 and 10 degrees north; longitudes 137 to 148 degrees east (Fig. 2). Yap State is geographically, and to an extent politically, divided into two areas: Yap proper and the outer islands or atolls. The 'outer' or 'neighboring islands/ atolls' constitute 15 low coralline atolls, island or island groups, while Yap proper represents four closely associated high islands: Yap, Tamil-Gagil, Maap, and Rumung. Total land area of these four islands is 100.4 km^2 and the climate is tropical, with a mean annual rainfall of approximately 3,000 mm, although there is a distinct dry season from April through May. A considerable portion of Yap's shoreline is fringed by mangrove forests, comprising 1,171 hectares or 12 % of the total land area. These forests are especially well developed at the mouths of drainage systems and on mud flats.

The outer islands consist of three raised coralline islands and 12 coral atolls. Two of the raised islands (Fais and Satawal) and 9 of the atolls (Ngulu, Ulithi, Sorol, Eauripik, Woleai, Ifaluk, Faraulep, Elato and Lamotrek) are inhabited. The total land area is only 18.71 km^2. Most of the atolls contain many small islands of which few are inhabited. The atolls are characteristically low with the greatest elevation

rarely exceeding 7 meters. The largest atoll, Ulithi, has a lagoon area of 474.32 km ^{2}, and has 49 islands/islets with a total land area of 4.66 km^2. Faraulep, the smallest based on lagoon area, has 2.34 km^2 of lagoon, and a land area of 0.42 km^2. The elevation of raised coral islands is much higher; the maximum elevation on Fais Island is 33 m. The land area of Fais and Satawal is 2.81 km^2 and 1.31 km^2 respectively. The major atoll marine zones are the open ocean, reef, and lagoon areas.

Yap State is one of the four constituents of the Federated States of Micronesia. The FSM was formed in 1979 and gained sovereignty in 1986 through the ratification by the U.S. Congress of the Compact of Free Association. While reliable estimates are currently not available, GNP per capita estimates put the FSM "to the lower end of the lower middle-income countries ($1,236 -2,555)", with external aid contributing about $1,200 per person in 1990 (World Bank 1993). For Yap State, traditional political structures are integrated into a modern representative government. The two Councils of Chiefs (one for Yap proper and one for the outer islands) have power of veto over legislation promulgated by an elected legislature where matters of custom or tradition are concerned (Article III, Yap State Constitution). A governor that presides over an administrative bureaucracy is elected separately. In practice, accession to government posts, whether elected, appointed, or within the bureaucracy, is heavily influenced by one's cultural ranking.

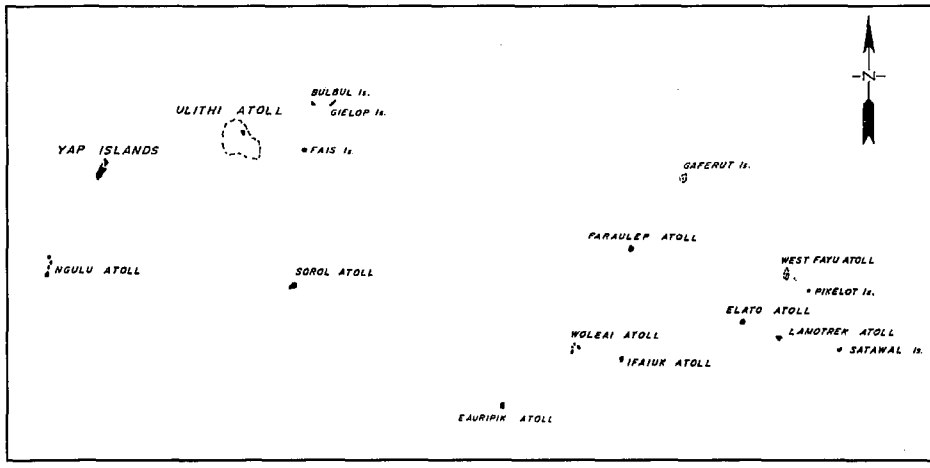

Figure 2. Yap State, FSM depicting Yap proper and outer atolls and islands.

The traditional rights of the people are protected by the Yap State Constitution. In relation to marine resources the constitution states:

> The State recognizes traditional rights and ownership of natural resources and areas within the marine space of the State, within and beyond 12 miles from island base lines. No action may be taken to impair these traditional rights and ownership, except the State Government may provide for the conservation and protection of natural resources within the marine space of the State within 12 miles from the island baselines (Article XIII, Section 5).

The languages of Yap proper and the outer islands are quite distinct from each other. Within Yap proper there are slight dialect differences between some municipalities only 40 km apart. In the outer

islands there are distinct dialect differences between the Ulithi, Woleai, and Satawal regions. English is the official language of government and the preferred language of higher education although many of the older generation, especially in the outer islands, are fluent only in their traditional language (FSM 1991) or in some instances Japanese.

In 1991, Yap State's population was 11,019 with approximately 7,000 in Yap Proper and 4,000 in the outer islands (World Bank 1993, FSM 1991). The natural population growth rate, excluding migration, is about 2.2% per annum; the real growth rate between 1973 and 1987 was 2%. The current population for Yap State is less than former highs before western contact which was estimated to have been somewhere between 25,000 to 50,000 individuals (Alkire 1989). Migration within the state is occurring primarily from the more densely populated outer islands to the municipal centers of Colonia in Yap proper and Falalop in Ulithi. The municipalities at the extremes of Yap proper (Rumung and Gagil) have also recently experienced population declines. Emigration patterns are currently unknown but believed to be significant (FSM 1991).

Yap State's waters are divided into the internal waters and the State Fishery Zone. The FSM Exclusive Economic Zone extends from 12 miles to 200 miles from the island baselines and is controlled by the national government based in Pohnpei. Internal waters are those from the shore to the island baselines, and the State Fishery Zone extends 12 miles seaward from island baselines. Because of the wording of Article 8, Section 5 of the constitution, traditional leaders have total control over internal waters; the government can intervene only for conservation and protection purposes. The government departments and agencies having direct responsibilities for the marine area and its resources are the Marine Resources Management Division (MRMD) and the Yap State Fishing Authority (YFA). The MRMD is primarily responsible for the conservation, assessment, and management of Yap State's marine resources along with fishery and aquaculture development projects; promotes marine environmental protection; and documents traditional marine knowledge. The YFA was created primarily to develop and implement commercial fisheries and other related activities. It is also empowered to conserve, manage, and carry out enforcement of Yap State's marine resources in the State Fishery Zone.

Despite differing cultures and languages, Yap proper and the outer islands have traditionally been linked by a system of political, economic, and religious ties (Alkire 1989). The tribute system, which ceased sometime around the turn of the century (Oliver 1989), obliged the outer islanders, at specified intervals, to send objects of tribute to the chief of Gagil district on Yap proper, as well as religious gifts to specific religious functionaries, and gifts from specific families to their Yapese `overlords' in Gagil (Alkire, 1989).

In Yap proper, power and authority are defined in terms of land. The *tabinaw* is the basic sociopolitical unit, and usually refers to one patrilineal household and is the traditional basis of land ownership (Oliver 1989). Several families or a clan may reside on lands belonging to a single named estate (*tabinaw*). This parcel ideally includes all important resources, such as several nonlocalized house and garden plots, parcels of taro patches, and sections of the lagoon for fishing. Villages of Yap proper are distinctly defined and run by a council consisting of the patrilineal heads of the *tabinaw*. Within a village there are many ranks, the highest of which are the chiefs "of ritual," "of the village," and "of the young men" (Alkire 1989, Sudo 1984). The "chief of the village" is the executive head and the economic leader.

Management of marine resources traditionally serves to support the hierarchical system of each network. Reef and lagoon areas are divided into differentiated areas and are associated with a particular *tabinaw* suggesting a **Type IV** classification tenure system (Sudo 1984). Marine resources are exploited for subsistence use, to support cooperative efforts within the network, and to support the head of the network. Access to fishing grounds, fishing gear and fishing rights is managed within the hierarchical

system (Smith 1991). In general, fishing methods involving the most elaborate equipment (such as special canoes and gear) were limited to ranked groups. Additionally, particular species are the property of certain higher ranked people. Traditionally the inshore waters of each village are within the jurisdiction of the village and except in the case of certain fishing methods, outsiders may be prohibited from exploiting its resources. Some fishing methods are available to all fishermen within a village while other methods, and sometimes the area within which they are used, are vested in certain estates. The lowest ranking villages have no land or fishing rights except for a few methods practiced in specified limited areas. The servant level has land but the title belongs to a high chief to whom they give the "first fruits" and other tributes and services (Alkire 1989).

Currently while most of the reef ownership boundaries--at least on the municipal and village levels--are universally known and accepted, most are routinely ignored (Smith 1991, Goldman et. al. 1993, Graham 1991). Permission is only occasionally asked to fish on another's reef area, and the catches of such activities are rarely shared with the reef owner. Traditional restrictions on gear ownership--especially nets--appear to be completely disregarded (or obsolete if modern gill nets are interpreted as not falling within those traditional restrictions) (Graham 1991). With few exceptions, customary exchanges or tributes of fish between villages no longer take place. Further, because fishing trips rarely require more than four or five fishermen, large scale distribution of catches on the village level rarely take place (although some villages are using modern variations of communal fishing). Certain *tabinaw* or individuals of each village or municipality are still recognized as responsible for resolving various aspects of disputes over infractions of customary fisheries law (Smith 1991, Graham 1991).

For the outer islands the major sociopolitical groupings are based on the matrilineal clans (Oliver 1989, Ushijima 1982). These clans are ranked upon the sequence of their arrival on the different islands (Ushijima 1982). Typically, the eldest son of the most senior woman in each clan is the chief (*tamol*). However, under some circumstances the eldest man of the most senior branch of a clan may be the chief. The clans are further divided into subclans, lineages, and descent lines.

In the outer islands the system of control and tenure of the marine areas and resources falls into three broad and overlapping categories (Sudo 1984). In all islands, however, the marine areas are not owned by the chief(s), but are only managed by them in consultation with the other clan elders ostensibly for the benefit of the whole clan (Smith 1991). In contrast to Yap proper, customary controls on marine usage are, for the most part, still strong in the outer islands. The systems of marine tenure, fishing rights, catch distribution, dispute resolution, and punishment are still observed (Smith 1991). There has, however, been a general relaxation in the enforcement of fishing rights (Smith 1991, Smith and Dalzell 1993). Currently there is a lack of any small-scale commercial fishing in the outer islands similar to the type occurring on Yap proper. This is due partly to the lack of opportunities, but, significantly, it is also a result of the overtly stated fear that commercial fishing will not leave enough reef fish for subsistence purposes. With one exception, the Council of *Tamol* regularly debates this issue and to date has erred on the side of restraint.

On Ulithi atoll, for example, all the reef and lagoon areas traditionally belong to the highest ranking clan. This clan's chief also presides as the paramount chief of Ulithi. The marine areas of the atoll are, however, divided into several subareas. Within each area on Ulithi are a number of sections that are controlled by the chiefs of each clan. The members of any clan have the right to fish in any section within the atoll that belongs to their clan. This system of tenure represents Sudo's (1984) **Type III** and is still basically in force today. A slightly different tenure and use rights system occurs on Woleai (Smith and Dalzell 1993). Here the reef and lagoon are divided up and controlled by the ranking clan on each island or village. There is no paramount chief who has jurisdiction over all Woleai. The head of each ranking clan, in consultation with the other elders, will control the clans own areas, deciding when and if they should be closed, as well as deciding upon communal fishing. Individuals can fish within their own clan's

areas anytime. While not as clearly defined as others, I tentatively classify the Woleai atoll marine tenure system as a **Type II**. The third form of tenure and use rights is exemplified by Satawal (Sudo 1984). Here the chiefs of the three ranking clans divide the responsibilities for island affairs. One chief takes the role of the "chief of the sea." He has the rights to control the usage of the marine resources and fishing methods. The use of the fringing reef area is open to any man who wants to fish there, but all other fishing areas (sea mounts, uninhabited atolls) require permission of the "chief of the sea". Propriety rights to use the food resources of the fishing areas other than the fringing reef belong to the chief of the sea. This system represents Sudo's **Type I** and is reportedly still in force today (McCoy per. comm., 1994).

The social organization, especially as it relates to marine resource usage and tenure within Yap State is very complicated as is evidenced by the tentative identification of all four of Sudo's marine tenure types. Further complications arise from the rights to certain resources within the distribution systems themselves and requires more focused study. For that I turn to the largest atoll in the outer island group, which fortunately was found by Bridgeland (1992) to have the most "potential" for sponge farm development.

ULITHI ATOLL - A TYPICAL CASE ?

Ulithi is physically the largest and most politically significant outer atoll in Yap State. In modern terms it is linked to Yap proper by at least quarterly visits by a field trip ship and weekly visits by private airplane service. The reported population is approximately 1,000 people living on five islands. Ulithi atoll traditionally played a significant intermediary role in what was called the *sawei*--an overseas exchange system. Specifically, particular land estates in either Gachapar or Wonyan village on Yap proper exert kinship relationships by which clan estates are "parents" and the people of the outer islands are viewed as "children." When Ulithians or people from Woleai (the next biggest outer atoll) go to Yap proper they are treated in the manner of a kindly parent toward a child--this system has diminished over the years but aspects are still found today.

Within Ulithi atoll are several political districts, each made up of several villages, with each district ranked according to status (Fig. 3). Ulithi physically occupies a traditionally strategic position connecting all of the other outer atolls with Yap proper, and it represents one of the three main political blocks in Yap State (also including the Gagil district on Yap proper and "Woleai"). Traditionally Ulithi was subordinate to Yap proper, as is Woleai to Ulithi. The paramount chief who lives on Mogmog in Ulithi acted as an intermediary between Woleai residents and as the chief of Gachapar village in the Gagil district in Yap proper. There was no direct communication between the chiefs on Yap proper and for instance Woleai; an internal communication chain of command distributed important information, but with the advent of modern transportation and communication this system has diminished greatly.

On Ulithi atoll, as is typically true of many outer atolls, each village comprises several land-holding lineages (*heilang*), with descent matrilineal, yet genealogical relations with the patriarch are not overlooked (Ushijima 1982). Matrilineality involves a succession of lineage by *tamol* (heads) and inheritance of land and taro pits. It is not unusual for land to be allocated individually and passed on to patrilineal decedents or for lineage-related office to go from father to son (as was seen to be the case on Yap proper). Marital residence is typically patrilocal, and therefore through dispersion and out marrying it is not unusual for a *heilang* to die out and to be displaced by members of a more prolific one. Post-marital residence is also patrilocal, so with women scattered among various residence groups, distribution of resources (foods and goods) tends to be relatively even among all families on an island despite social stratifications.

All activities traditionally came under the jurisdiction of the paramount chief residing on the island of Mogmog historically considered to be the central district (Ushijima 1982). Mogmog has one main village, divided into two sides depending on familial or clan ties (true to this day) relative to the founding clans of Ulithi. The *tamol* (head) of the eastern-side of the island is considered the paramount chief over all of Ulithi. It is believed that the first settlers on Mogmog came from the east, and political power resides in the founding families on the atoll (Ushijima 1982, Alkire 1978). Traditionally the head of the original lineage is considered the paramount chief, he in turn has designated power or administrative control over all of the land, lagoon and reef areas of Ulithi to a second *heilang tamol* (equivalent of a "governor"). Mogmog village council chiefs (*metang*) are the *tamol* from five founding *heilangs*. The *metangs* are privileged in that they receive a special share of resources and tributes such as particular types of fish, turtles, and the occasional whale. Generally most *heilangs* on Ulithi control some portion of terrestrial parcels or swamp land; however, reef and lagoon areas are controlled only by the most powerful *heilangs*. On Ulithi, fishing is men's work, while women tend to households, taro pits, and gardening work. This division of labor is clearly defined and is reported to be currently maintained (Ushijima 1982).

Ulithi atoll reef (*yots*) and lagoon (*i bong*) areas are divided into distinct districts with complicated control and use patterns. All islands and lagoon areas, whether inhabited or not, have economic use and therefore access is controlled by a *heilang*, represented normally by a *tamol*. The paramount chief on Mogmog maintains eminent domain over all islands, lagoons, and reefs within Ulithi atoll. Additionally, the governor chief controls all on Ulithi on behalf of the paramount chief. Below him are chiefs (*rat*), who gain succession through specified *heilangs* and directly control access to reef and lagoon sections. Each stretch of reef and lagoon area is identified and ranked (see Fig. 3). Mogmog is the most powerful section, with the adjoining reef and lagoon area controlled by the office (*rul*) of the paramount chief, but a second family's *tamol* is the *rat*. A council *metang* may or may not have jurisdiction over marine access, as with the governor, but obviously all of these entities have some influence and controlling interests on matters related to activities with in these areas. The chiefs that act as *rat* control and oversee the islands/islets, their inhabitants and marine resources and have the prerogative to receive the "first fruits". Those who fish in the lagoon present some of their catch to the *rat* who controls the relevant lagoon section. According to sources on Mogmog this system is still basically in use today for most of the atoll.

The proportion of the catch reverting as the chief's share (*fath*) is a direct manifestation of control exercised. There are certain marine resources and methods of capture that continue to be reserved for specific control within the lagoon. Green turtles (*wö*) have significant social, economic, and cultural value on Ulithi. Typically turtles become available during the breeding season (May-July) and are caught while coming ashore on uninhabited islands of the atoll. Any green turtles caught must be sent Mogmog for distribution. Green turtles are slaughtered and ritualistically distributed. The basic division of the turtle as described by Ushijima (1982) is interpreted in Table 3.

Traditionally the turtle catchers received anywhere between an estimated 35-45% of their actual catch but not the better parts. Another resource and distribution reserved for the ranked *heilang* is that of the occasional dead whale found adrift. Typically both animals were divided from the Mogmog men's house. Because the proportions can be relatively large these individuals in turn would distribute meat to other *heilangs*, potentially outside of Mogmog, but the distribution is clearly controlled by the ranked hierarchy. While there has been some break down and relaxation of this system, those interviewed on Mogmog maintain that this system is to a degree still exercised. In the case of fish, the division and tribute system tends to vary depending on the type of fishing technique used, when employed, and by whom. In the case of trawl-line fishing (see Smith and Dalzell 1993) and bottomfishing, typically the paramount chief's share is a large fish from each island. Additional tributes known as the *Laliru Tamol* (day of the chief) involve all fish caught during a 5-day period. The fish are boiled or smoked then brought to the Mogmog

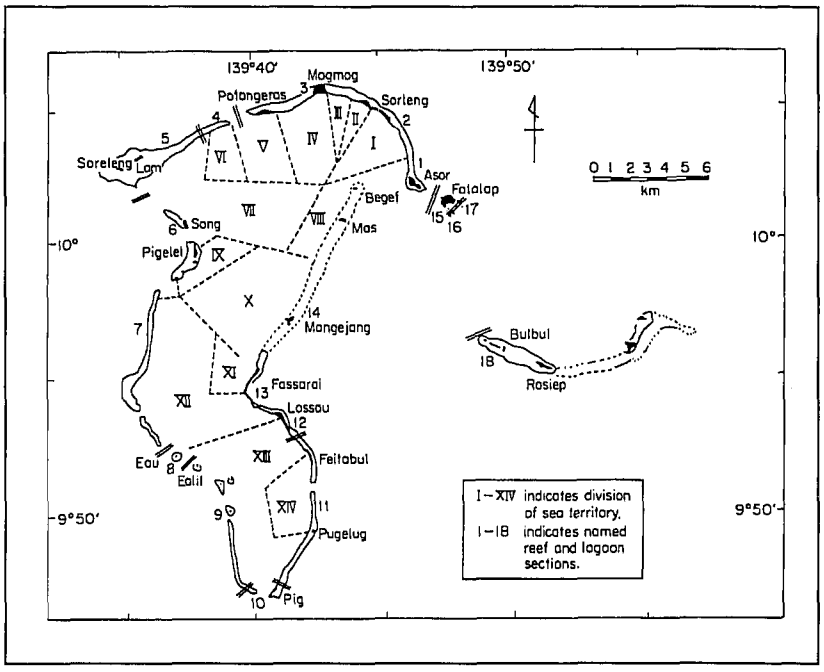

Figure 3. Ulithi atoll reef and lagoon districts (adapted from Sudo 1984).

men's house for distribution. Offerings are made to deities, and the paramount chief and governor get large shares. Any remainder is distributed to the women of Mogmog.

DISCUSSION

As demonstrated by Croft (1992, 1993) and described by others (Bridgeland, Stevely and Adams, etc.) sponge farming is not complex by western standards. It involves basic husbandry techniques of the most rudimentary nature. However, for outer atoll residents it should not be viewed as such. Pollnac (1978) indicates that **Complexity** is a relative measure. For outer atoll residents, sponge farming should be viewed in aggregate as a relatively complex undertaking, but actual farm setup appears to be within indigenous skill levels. Farm establishment requires skills common to most outer atoll fishermen; i.e., the search for sponge seedlings (especially given the baseline work of Bridgeland at Ulithi), and does not fall outside of the cultural norms described. Croft (1993) suggests sponge mariculture training activities are straightforward for motivated individuals, and the information here appears to confirm his premise. However, as described below (Observability) it may be necessary to provide a number of intermediate goals to allow tangible demonstration of relative success. These may include financial renumeration before initial harvest and would require a pool of reserve capital during the initial grow-out period. Of additional importance is how farm trainees are chosen. Typically one can expect male individuals with social status and the appropriate physical attributes to be nominated by local authorities to receive training. Individuals with low social status, while potentially motivated, may become disenchanted if they are precluded from the fruits of their efforts. Therefore, those who actually labor on the farm must be carefully selected and must have sufficient status to allow them access to any benefits (either through wages or profits).

Table 3. Distribution system for green turtles in Ulithi atoll as reported by Ushijima (1982).

Turtle Body Part	Est%	Receiver
Head	5	Fashilith *tamol* (head)
1/2 breast meat	10	Menstrual house
1/4 breast meat	5	Fashilith heilang (family)
1/4 breast meat	5	Numurui *heilang* (family)
1/2 entrails	15	Fashilith *heilang* (family)
1/2 entrails	15	Numurui *heilang* (family)
Shell	20	Catcher(s)
Legs	10	Catcher(s)
Eggs	5-15	Catcher(s)
	≅100%	

The appropriate vehicle for introduction of sponge farming as an economic activity or as a technological innovation requires careful consideration. Typically new economic ideas or innovations can be introduced by three basic mechanisms: observation by an insider, who in turn attempts it locally; government intervention; and finally through exogenous mechanisms such as outsiders, private business interests, and investors seeking profitable opportunities. On Ulithi atoll, it is highly unlikely that an atoll resident will independently investigate ongoing sponge farming activities in Pohnpei. While this possibility should not be totally precluded, given the capital and technical requirements, this mechanism is discounted until such times as sponge farming is locally (Yap proper) demonstrated as a viable economic activity. A possibility does exist that an appropriate individual(s) may be sent from Yap State to be trained in Pohnpei, but the individuals must have the appropriate social status **and** the resources to implement the sponge mariculture activities.

With the completion of the field assessment by Bridgeland (1992), there has been some discussion by individuals at the Yap State MRMD on soliciting interest from the atoll councils or via the Council of *Tamol,* about the establishment of a government supported demonstration farm. This mechanism will require close coordination between traditional and modern governance systems. Yap State MRMD has demonstrated its ability to complete discrete outer atoll projects (e.g., trochus seeding) but does not have a history for sustained extension or program activities. Additionally, MRMD recently completed a marine resource management plan that includes a process for approval of outer atoll marine resource development activities (see Goldman et. al. 1993). Unfortunately, the marine resources management plan proposes complicated mechanisms for the approval and initiation of marine resource development activities, especially those proposed by the private sector. The procedure described is untested and appears to be very bureaucratic. Only time will tell if the proposed management scheme will be approved, much less implemented. But if implemented, it is questionable how many projects will be able to obtain the requisite approvals.

The third way of introduction is via an independent entrepreneur interested in sponge culture as an economic investment. While such ventures typically assume profit maximization as the sole decision criterion, there are a variety of possible scenarios that could include equity considerations leading to

sustained and mutually beneficial arrangements for all parties concerned. However, consideration must be first given on how to obtain permission in a 'culturally correct' context, abstracting from permits and requirements of the modern governance system of Yap State and the FSM. If one is not attune to the traditional systems and their current manifestations (even if one could obtain unrestricted access to seed stock and lagoon space for grow-out) establishment of a private farm that ignores social norms would, in the long run, cause considerable social upheaval and conflict. The repercussions would in all likelihood reach back to Yap proper, given traditional relationships, and be refracted into modern governmental structures. Therefore, I suggest an 'outsider' would have to spend considerable time establishing relationships with a variety of individuals or work with someone who has the appropriate "connections," and even then obtaining permission and long-term tenure may prove impossible.

In the traditional context one would have to establish a relationship with the individual estates on Yap proper first. The process would next involve the appropriate Yap *tabinaw* depending on exactly where one plans to situate the farm on Ulithi and through whom one plans to be associated. Once permission was obtained from the appropriate traditional authorities on Yap proper, the permission of the paramount chief of Ulithi was crucial, after which the permission of the "governor" and the council of elders was obtained. At this point one begins negotiations with the *rat* for access rights to the farm site. If the site does not lie within a sector containing sponge seed stock, then permission must be obtained from the appropriate *rat* for exploitation of sponge stocks. The current system of approval appears to be truncated in that the tribute and control traditionally exercised by certain villages on Yap proper has shifted to greater control by the Yap State government, Yap State MRMD, and particularly the Council of *Tamol.* Currently, the Chairmen of the Council is from Mogmog but reportedly there is no paramount chief on Ulithi. Currently, one must still obtain the approval of the Island Council on Mogmog, along with the *rats* of the specific site of the proposed growout activities (and the site of where the brood stock were to come from if different). Nonetheless, the potential complications arising out of such a sophisticated chain of command are self evident. These complications will surely intensify as one contemplates actual costs and specific access rights.

Comparability --Stevely and Adams (1993) indicate that after initial setup a 1-acre farm requires between 22-64 hours per month of maintenance and processing labor (Table 1). An important determinant will be how this work is viewed by Ulithians. The work may be perceived as fishing (unlikely) or more akin to tending of the taro patch, an agricultural function that historically has fallen to females. This facet may prove to be an area of possible conflict as females become the dominant factor in successful farm maintenance. Consideration should focus on what the potential cost to traditional roles will be. An even greater unknown is how the various traditional leaders on Ulithi will come to view sponges within the contemporary marine resource allocation context. Bridgeland (1992) suggests this decision should be left to the Council of *Tamol,* however, it may not be that simple.

Many researchers stress that different attributes such as type, place of origin, and method of capture, all bear significantly on how marine resources are utilized and who has rights of access (Ushijima 1982, Smith and Dalzell 1993, Smith 1991, Alkire 1978, 1989). For Ulithi, Ushijima (1982) describes in detail how certain resources are reserved for the various *rats', metangs',* and *Tamils'* precluding egalitarian distribution systems espoused in western society. Whales, turtles, and large fish represent what economists may regard as the 'renter' items of the protein depauperate economies of traditional outer atoll life. Whether due to their intrinsic nature (size, food or protein value) or other intangible factors, these items allow for excesses beyond standard protein sources (taro, breadfruit, small fish) and provide "super normal" benefits. Even the more common staples are provided to the various authority figures as "first of the season fruit." These tributes temporally represent items of high value (in the same way as the first strawberries of the year are expensive in our society). If the paramount chief, or his lieutenant, decides sponge mariculture with its potential to provide significant economic benefits (rent) is akin to whales or particular types of fish, then it can be expected that the ruling hierarchy will be involved in <u>all</u> phases of

sponge farm development. This will in all likelihood include complete appropriation of all revenues as a result of any products produced and sold. From an outside or foreign partner's point of view this may prove untenable and preclude any willingness to invest in sponge farm development.

Complete appropriation may not be the case as shown with the green turtle distribution (Table 3). The right of the individual captor(s) is recognized even with marine resources of high cultural and economic value. While an investor would in all likelihood not be willing to get involved if profits were distributed in exactly this manner, the precedent does exist for non-exclusive use of valued marine resources. A system could be devised similar to the case of whale meat distribution, where profits or revenues from sales would be distributed among the five ranked *heilang*, with benefits to the greater community obtained through distributions or "trickle-down systems." Conversely, the traditional power structures may view sponges outside their direct control and require only that the appropriate *rat* permission be obtained to initiate sponge farming activities. In this instance the benefits may be localized to a particular *heilang*. Finally there is the example of trochus or topshell harvests (which traditionally was not heavily exploited in the outer atolls) where the benefits go directly to the individual who does the actual harvesting. Though even for trochus, harvests are strictly controlled, as are areas harvested.

Advantage--Stevely and Adams (1993) in their analysis suggest that substantial return can be expected from sponge farming in Pohnpei lagoon. While their analysis extrapolates from a small data set and application to the outer atolls will probably reduce return on investment to assume that positive returns can be obtained with proper farm management. As described above, outside investors will seek some form of control or assurances that their investments will be protected and will potentially yield positive returns. However, while low by western standards, the capital required to initiate activities (buoys, lines, tools etc.) is typically beyond most *heilangs*' capital accumulation abilities given low cash earning potential as demonstrated by per capita GNP data. The accumulation of capital or resources of the magnitude required to enter into sponge farming is counter to traditional practices and would represent at least one years' cash expenditure for a typical *heilang*. There may be individuals who are able to obtain required capital or who can access it through various channels (school teachers, government workers, store owners etc.) but in all likelihood even these would require outside assistance. Therefore, foreign (to Ulithi) investment would be required and specifically how this occurs could lead to substantial conflict and social disruption (as discussed above).

Trialability--this attribute has been touched upon earlier in the Comparability and Advantage discussions with respect to the willingness and ability of individuals in the outer atolls to become involved in sponge farming. Clearly individuals with access to appropriate technology and information related to sponge mariculture may be positioned to take advantage of opportunities; however, the traditional powers on each atoll/island must be incorporated. With the complex clan stratification system on Ulithi, a minimum of at least one of the five ranked *heilangs* must be involved. Obviously individuals not possessing the appropriate rank or resource rights, no matter how intelligent or wealthy, will not be allowed to operate unimpeded within the lagoon. The disruption of this basic social norm will prove untenable, even with state or national government support. Besides capital and knowledge requirements, the next most (if not the most important) factor required will be land, or in this case, lagoon space. Once adequate sponge stock is located within a lagoon, determination of the optimal farm site should include consideration of traditional control and marine-use systems before biological considerations (in contrast to aquaculture conventional wisdom). The determination of lagoon tenure or use rights for farming may be the penultimate determinant of long-term success.

As demonstrated in Ulithi, all reef and lagoon areas are controlled by a variety of mechanisms. While the paramount chief traditionally exercised ultimate control, his powers were shared by a number or hierarchical layers. Given that reportedly there is no current paramount chief, local control will fall to the Mogmog island Council and the *rats* of the particular district in which the farm is to be situated.

Accordingly, all of those who currently use the area will have to be consulted to determine what other access or activities may be disrupted because of farm placement. Bridgeland (1992) indicates that *S. officinalis* beds were found in two specific lagoon sections (**X** and **XIII**, Fig 3) and could provide placement of initial farming activities. But in the long run, due to the rank of Mogmog in the traditional system, sections **II** and **III** may prove politically more palatable. Siting can only be definitively determined after consultation with appropriate leaders on Ulithi and after consideration of the use of existing resources at a designated farm site.

The application of Sudo's (1984) model indicates that all four types of marine tenure systems described for all of Micronesia can be found in Yap State. All systems are viable for sponge mariculture; however, from a purely economic perspective those that offer the greatest prospect of exclusion, with **Type VI** (found on Yap proper) and **Type III** (found on Ulithi) offer the best options from a economic perspective (exclusivity and secure tenure). But as discussed above, other factors may prove to have equal or greater consideration in the development of an outer atoll sponge/mariculture operation.

Observability--Croft (1993) alludes to potential problems with this attribute given his experience in Pohnpei. Consequently, he recommends that extension agents provide encouragement during the initial 2-2½ year grow-out period before the first harvest and concrete demonstration of potential benefits (i.e., first sale of sponges). In all likelihood even if extension services are established in FSM, they will be confined to the urban centers on the main islands (Pohnpei, Yap proper, Kosrae, Weno in Chuuk). The prospects of constant or repeated visits by aquacultural extension agents to the outer atolls are considered poor, given distance and travel requirements especially for those atolls that are not served by air.

Given the grow-out period between planting and harvest, it is reasonable to assume that the perception of success may diminish to a point where little or no maintenance will occur. Croft (pers. comm. 1993) indicates this scenario may not necessarily result in complete failure as often happens for most species (giant clams, pearls, seaweed). Rather, unless there is significant human intervention, pilferage, wanton destruction (rated a low possibility), a catastrophic environmental event (typhoon), or infestation by fouling organisms (tunicates, soft corals, etc.) or the array lines break, the sponge seedlings should do fine on their own. This subattribute is one of the factors that makes sponge farming appealing for the Micronesian setting. Typically all Micronesians, and to a greater extent all outer atoll residents, are socially compelled to participate in ceremonies that may extend for days, if not weeks (deaths, weddings, religious events). Experiences on Pohnpei have shown that farms can be left unattended for months without significant problems; however, this is not encouraged and has not been tested for periods of 6 months or more. The same appears true for outer atoll settings.

The initial demonstration of sponge farming in the outer atolls of Yap has been advocated by some via the establishment of a community-based farm (Bridgeland, 1992). While systems of traditional and modern control are well established and sources of public sector support (via capital, training) are available, a substantial body of empirical and theoretical data suggests that farms operated in this manner tend not to be economically sustainable over the long term. Previous experience in FSM demonstrates that over time, these operations require continued subsidization. Outer atoll power and social structures may rationally view the initiation of a government-supported project as a extension of social assistance activities and become unable to differentiate the need for profit or surpluses over social welfare. Given the current weak fiscal status of the FSM and Yap State modern governance structures, one must scrutinize such ventures, weighing all costs and benefits. After considering costs and benefits, and an incorporation of an element for risk given the inability to anticipate all factors, one then needs to decide how this type of activity compares to other economic and social welfare options available in the outer atoll setting.

CONCLUSION

Sponge culture appears to be biologically suited for the outer atolls of Yap State but while the evidence suggests the technology required to establish a farm can be transferred to Ulithi atoll there are a number of important concerns which will determine its sustainability. An obvious area for future social research is how actual farm maintenance causes disruption of traditional gender roles. The data presented here suggest it may be a significant concern requiring further evaluation. While not conclusive, the economic information suggests positive return to investment can be obtained from an outer atoll sponge farm; however, profit levels may not be as high as those predicted for operations located closer to markets and international shipping links. Demand for natural sponge is currently strong and expected stern standards, is felt to preclude indigenous development. As demonstrated, private investment will be possible only after adherence to a complicated approval system. Community-based farms provide an alternative mechanism but should be assiduously monitored if in fact economic independence is an overt goal of any development scenario. The Yap State Marine Resource Management Division can and should provide assistance to potential farmers, but the impetuous should be indigenous. Efforts should be made to minimize "outside" experts and tendencies to disrupt local economies by paying labor in excess of opportunity wage rates. These tendencies along with a lack of economic development experience suggest that direct governmental intervention should not be encouraged.

Modern government, however, does have a role to play in sponge mariculture development in Yap State via communication, training, assistance with farm establishment, extension services, and eventual monitoring. Training is currently available through a variety of national and international sources, and farmers must be provided encouragement during initial grow-out periods. This may require the application of significantly greater up-front capital than proposed by current economic feasibility studies. The prospect for successful development of sponge farming in the outer atolls of Yap State, or for that matter any economic activity, will be determined by who benefits and who loses. Traditionally, the determination of winners and losers was based on kinship and lineage, a system which remains strong today. Outsiders are needed for capital and technological inputs, but they must be aware of the rigidity of these systems and the need to minimize social disruptions.

While the specifics provided herein are clearly unique to the case presented, a number of general hypothesis can be drawn. By employing a number of data sources, both those traditionally used for project or business appraisals (economic and technical) along with social and cultural information one can better understand the opportunities and constraints to development initiatives. The highly touted, but seldom employed integration of social science models, with information from sources typically employed by economic and mariculture developmentalist, force broader perspectives. The results suggest that even rudimentary analysis such as those employed here provide meaningful insights. Situations which initially appear straightforward and homogenous suddenly reveal nuances that may prove critical to planning and investment decisions. Systems and processes, deemed from one perspective as simple may when cast in the anticipated setting prove especially convoluted or untenable. Simple innovations may or may not be readily accepted despite incentives to do so. Nor may their greater implications, especially if long established social or cultural values are cast aside as a cost of the development process. Simple (and common) human traits such as jealousy, or the connotation of jealousy, in a small island community can be considerable.

Successful mariculture development, or for that matter sustainable development in general, may depend most heavily on cultural and social factors more so than technical or economic constraints. Each case must be viewed with in its own context. If the sustainable development paradigm, and in turn the sustainable aquaculture mantra is to have real meaning or applicability in Pacific insular settings the paradigm must shift to include the appropriate perspective, and all facets should be formally evaluated when possible.

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