A cultural consensus analysis of marine ecological knowledge in the Solomon Islands

Kevin L. Grant[1] and Marc L. Miller[2]*

Abstract

Scientific interest in "local" or "traditional" marine knowledge and its applications in fishery and resource management have fostered linkages between the fields of marine biology and cultural anthropology. Ethnographic techniques are useful for investigating local knowledge structures, but these methods are time-consuming. In partial remedy, this paper promotes the technique of cultural consensus analysis. This Solomon Island case study focuses on ecological knowledge regarding the Arnavon Marine Conservation Area (AMCA) and marine areas that are not officially regulated (gazetted). Study respondents reside in the Isabel Island communities of Poro, Guguha, Kia and Allardyce. Results confirm that there are two bodies of marine ecological knowledge for the marine areas in question with two compatible sets of "culturally correct" answers to the ecological propositions of interest. Findings have potential value in the Solomon Island marine protected area context for their significance with regards to communication, resource assessment, human resources, and resource management. Cultural consensus analysis promises to be of methodological value to marine protected area and fishery managers elsewhere, and can support a variety of management and conservation endeavors attuned to the ideal of sustainable development.

Introduction

In the marine context, scientific interest in "local" or "traditional" knowledge originated in the late 1970s. Fundamental questions concerned natural resource ownership and sea tenure systems, and taxonomic distinctions and fisheries systems. It is important to know that the resulting literature reflects a cross-fertilisation between marine biology and cultural anthropology (Johannes 1977, 1978, 1981, 1982; Akimichi 1978; Ruttley 1987; Hviding 1988, 1989; Ruddle 1993; 1994; Aswani 1997, 1998; Foale 1997; Hamilton and Walter 1999).

Today, it is widely accepted that ethnoichthyological, ecological and other forms of local knowledge are pertinent to marine resource management. In the collection of local knowledge data, scientists have promoted the use of ethnographic techniques such as participant observation, social surveys, and both formal and semi-structured interviews. Analyses have been both quantitative and qualitative (Polunin 1984; Ruddle et al. 1992; Johannes and Hviding 2000; Pollnac et al. 2001; Johannes 2002; Sabetian 2002; Aswani and Hamilton 2004). Drawing from the insights of Christie and White (1997) and Clark and Murdoch (1997), Hamilton and Walter have pointed out that these skills are "usually difficult, time consuming and well beyond the professional training of most fisheries scientists, resource planners, and project managers working in island Melanesia" (1999:13). It seems obvious that this observation holds elsewhere in the Pacific and beyond. With this background, this paper discusses the powerful and inexpensive technique of cultural consensus analysis, and reports on local ecological knowledge in the Solomon Islands.

Cultural consensus analysis

In conversational terms, cultural consensus analysis is a formal and mathematically warranted software procedure for examining a database consisting of respondents' "true-false" judgments about a set of propositions. In this case, the propositions in

1. Master of Marine Affairs, School of Marine Affairs, University of Washington, 3707 Brooklyn Ave. NE, Seattle, WA 98105-6715, USA. Email: keving73@u.washington.edu or Kevin.Grant@noaa.gov
* Contact author
2. Professor of Marine Affairs, School of Marine Affairs, University of Washington, USA

question have to do with the ecological knowledge of Solomon Islanders. Importantly, the propositions of interest must concern beliefs (i.e. what people have concluded about reality or what they, in the course of daily life, assume to be true or false) and *not* preferences (i.e. what people desire given alternatives) or value judgments (i.e. what is good or bad).

Cultural consensus analysis is based on a cognitive conceptualisation of culture. It has the potential to be of enormous methodological value for cross-cultural, ethnographic and sociological studies in which fieldworkers seek to describe knowledge structures (also referred to as concordance codes) that have currency in (sub)cultures other than their own. Consensus analysis is well suited for application in environmental and natural resource anthropology (Miller et al. 2004).

Culture

In this paper, we take "culture" to broadly denote what people *learn* and *know* in order to behave practically and appropriately (or knowingly impractically and inappropriately) in society. Somewhat more specifically, culture consists of the organised (i.e. systematised, patterned) distinctions, standards, and rules concerning reality and human choices that people, to varying degrees, share. Culture undergoes change as it is built upon or otherwise modified by individuals, and as its features and (dis)advantages are communicated to others. This definition derives from others within the tradition of cognitive anthropology that have held that the regularities of culture can be investigated scientifically (see: Romney and D'Andrade 1964; Tyler 1969; Spradley 1972; and D'Andrade 1995).[3]

In a well-known paper, Goodenough ([1957] 1964: 36) advanced a cognitive definition of culture:

> "[A] society's culture consists of whatever it is one has to know or believe in order to operate in a manner acceptable to its members, and do so in any role that they accept for any one of themselves. Culture, being what people have to learn, as distinct from their biological heritage, must consist of the end product of learning: knowledge in a most general, if relative, sense of the term. By this definition, we should note that culture is not a material phenomenon; it does not consist of things, people, behavior, or emotions. It is rather an organization of these things. It is the forms of things that people have in mind, their models for perceiving, relating, and otherwise interpreting them."[4]

Goodenough ([1957] 1964: 36) called for a theory of "conceptual models," and suggested that the adequacy of such a theory could be scientifically evaluated:

> "… by our ability to interpret and predict what goes on in a community as measured by how its members, our informants, do so. A further test is our ability ourselves to behave in ways which lead to the kind of responses from the community's members which our theory would lead us to expect. Thus tested, the theory is a valid statement of what you have to know to know in order to operate as a member of the society and is, as such, a valid description of its culture. Its acceptability beyond this depends largely on the aesthetic criteria to which scientists and mathematicians customarily refer by the term 'elegance.'"

In a volume published at about the same time, Goodenough (1963: 258–259) again equated culture with shared rules and perspectives, noting that when most anthropologists speak of a "community's culture" they have in mind:

> "…the things we attribute to its members' heads and hearts in order to make sense out of what they do. … Culture, then, consists of standards for deciding what is, standards for deciding what can be, standards for deciding how one feels about it, standards for deciding what to do about it, and standards for deciding how to go about doing it."

Three decades later, Chick (1997: 286) has reached roughly the same conclusion:

3. In considering the anthropological lexicon, Chick (1997: 284–284) classifies definitions of culture in four categories on a scale of increasing inclusivity: 1) culture as mental; 2) culture as mental and behavioural; 3) culture as mental, behavioural, and material; and 4) culture as information.
4. Goodenough ([1957] 1963: 36) considers "behavior or social, economic, and ceremonial events and arrangements as observed material phenomena" and as artefacts of culture. This view is arguably consistent with that of D'Andrade (2001: 249) who points out that:
   > "[I]t is a mistake to treat culture as consisting of nothing but ideas, meanings, understandings, and so on. Definitions, to be useful should 'carve nature at the joints'. But, cultural ideas/meanings/ knowledge/understandings are always fused to physical manifestations."

> "[M]y guess is that most anthropologists would favor a definition that includes culture as something in the heads of members of particular societies."

Origins of cultural consensus analysis

Consensus analysis has its origins in the confluence of mathematical anthropology and psychometrics (e.g. Romney et al. 1986, Romney et al. 1987; Batchelder and Romney 1988: 4700–4701). As Romney et al. (1996) point out in a recent special inaugural article by members of the National Academy of Sciences that appeared in the *Proceedings of the National Academy of Sciences*:

> "Cultural consensus analysis consists of a family of formally derived mathematical models that simultaneously provide an estimate of the cultural competence or knowledge of each informant and an estimate of the correct answer to each question asked."

Cultural consensus analysis shows great promise in the social sciences not only for what it will help investigators to discover about cognitive structures, but also for its surprisingly small sample size requirements. A first key feature of the cultural consensus theory is that it permits the recovery of culturally correct answers without knowing these in advance, as well as measurements of the competence of respondents. In this regard, Romney et al. (1996: 4701, emphasis added) have noted that:

> "[t]he consensus model provides a way to utilize much of the accumulated knowledge of traditional psychometric test theory without knowing the 'correct' answers in advance. Whereas traditional test theory begins with 'performance' data (i.e. items coded as 'correct' or 'incorrect') consensus theory begins with 'response' data (items coded as given by the informants; for example 'true' or 'false,' with no assumptions about whether the informant is correct or incorrect). The potential implications of this fact for the behavioral sciences may be important. *It means that we are now in a position to measure the knowledge of subjects where we do not know the answers to the questions we ask and to do so with a degree of accuracy comparable to that obtained in traditional test theory.*"

A second key feature of cultural consensus theory is that when the average level of cultural competence of respondents is found to be above 0.5, researchers can be certain of their results at traditional high levels of statistical confidence with sample sizes of between 4 and, say, 30 respondents. As Romney et al. (1986: 333) report:

> "This is the first time, to our knowledge, that we can defend at the formal mathematical level, the use of such small samples for the aggregation of cultural knowledge."

With these advantages, the methodological significance of the development of consensus theory is difficult to overemphasise. Fortunately, the case for cultural consensus analysis is most succinctly made by Romney et al. (1986: 327, emphasis added):

> "The use of the method with small samples of subjects and items is in rather striking contrast to related psychometric methods. For example, Nunnally (1978: 262), among others, recommends sample sizes of 300 to 1000 and the use of a large number of items with 'at least five times as many persons as items,' Lord and Novick (1968) present figures based on a sample of 107,234 cases. Lazarsfeld and Henry (1968) use a small number of questions but say we should have samples of subjects of at least 1000. *Are we really justified in using as few as a half-dozen subjects with only a few dozen items? We feel that the answer is yes for the following reasons: (1) we have a very tight theory whose assumptions are very stringent; (2) we are working with very high-concordance codes where consensus is high; and (3) we are only trying to find one 'correct' answer for a question rather than, say, differentiating questions on a continuous scale of tendency to be 'true' or 'false'.*"

The cultural consensus paradigm

In its most specific meaning, cultural consensus analysis refers to formal mathematical models developed by A.K. Romney and his associates. For an overview of how consensus analysis is linked to a host of data collection techniques (including, for example, pile sort, triad, paired comparison, and other judged similarity tasks that have become standard in cognitive anthropology) and quantitative methods (e.g. multidimensional scaling, hierarchical clustering, quadratic assignment procedure), see Weller and Romney (1988). For integrated personal computer software concerning the transformation and analysis of these types of data, see Borgatti (1996a).

As mentioned above (and when assumptions of the models hold), consensus analysis generates estimates of the amount of cultural knowledge possessed by subjects, and also "correct" answers that characterise the knowledge base under study. In what follows, the core of the cultural consensus analysis paradigm is briefly summarised. For more detail regarding the three assumptions — of common truth, local independence, and homogeneity of items — of the cultural consensus model, see Romney et al. (1986: 317–318).

Cultural consensus models treat a matrix of input data measuring how individuals (each of whom is typically associated with a matrix row) evaluate the "truth" or "falseness" of propositions, the "correct" answers to multiple choice questions, and (when pile-sort data is utilised) whether or not pairs of stimuli "belong together."

Very explicitly, consensus theory enables the researcher to answer three basic questions:

1. Is there enough agreement among respondents about propositions to indicate that all respondents *share a single knowledge base* or cultural code about the propositions? Alternatively, are respondents better characterised as having no consensus about the propositions, or as being committed to more multiple cultural codes?
2. If respondents do share a single cultural code, what are *the response differences* between individual respondents or subgroups of respondents?
3. If respondents do share a single knowledge base, what are *the culturally correct answers* to the propositions?

In addressing these questions, cultural consensus analysis systematically compares the pattern of a particular respondent's responses with patterns of all other respondents. This comparison of row vectors yields three kinds of output:

1. a *competence score* for each respondent indicating the level of knowledge of the cultural code (i.e. the extent to which the respondent's answers are *reliable* estimates of the answer key)
2. an estimated *answer key* displaying the culturally correct answers to propositions presented to respondents
3. a *similarity matrix* displaying the correlations for all pairs of respondents.

Consensus analysis applications

Over the last 15 years, diverse cultural populations and knowledge domains have been studied with consensus analysis. To illustrate, published studies have focused on college students and almanac questions (Romney et al. 1986), Guatemalans and diseases (Romney et al. 1986), folk medical beliefs (Garro 1986), child abuse (Weller et al. 1986), causes of death (Romney et al. 1987), expert and novice knowledge of fish (Boster and Johnson 1989), occupational prestige (Romney 1989), personality beliefs in a college sorority (Iannucci and Romney, 1990), alphabet systems (Jameson and Romney 1990), pollution and food safety (Johnson and Griffith 1996), social networks (Klauer and Batchelder 1996), cross-cultural cognitions of dental pain (Moore et al. 1997), boundaries of Celtic cultures (Caukins 2001), AIDS and other diseases (Weller and Baer 2001), and diabetes (Garro in press), and most recently, a pelagic fishery in Hawaii (Miller et al. 2004).

Against this backdrop, the present study extends cultural consensus theory from the realm of methodological development to that of application, in this case ecological knowledge of Solomon Islanders.

Case study

The research on the ecological knowledge of Solomon Islanders reported in this paper was undertaken in the context of a larger interest in natural resource management and marine protected area management in the Pacific (see, for example, Ruddle 1994; Christie and White 1997; Kelleher 1999; Roberts and Hawkins 2000; Christie et al. 2002; Aswani and Hamilton 2004; Christie 2004). In the Solomon Island case study we were particularly interested in the differences, if any, between areas that were not officially protected (gazetted) and the Arnavon Marine Conservation Area (AMCA – est. 1995). Our work finds modest justification in two recent assertions:

> "The practical, behavior-oriented, and observation-based nature of [Solomon Island] people's knowledge of the marine environment … is relevant to fisheries management … in the sense that it provides an admirable basis for the monitoring of fish stocks." (Hviding and Baines 1994: 28)

> "[In the Solomon Islands] the success or failure of conservation efforts largely depends on the attitudes of the communities owning them." (Sulu et al. in press.)

Setting

The Solomon Islands lie east of Papua New Guinea and northeast of Australia in the South

Figure 1. Solomon Islands, with research sites highlighted

Pacific. It is the third largest archipelago in the South Pacific. Land accounts for only 27,556 km² of the Solomon Island's total area of 1.35 million km². There are nine provinces comprising 992 islands, only 347 of which are populated. Coral reefs and lagoons surround most islands, and tropical rainforest covers approximately 79 per cent of the country (Honan and Harcombe 1997: 21). The field site comprised the Arnavon Islands (AMCA) and the Santa Isabel communities of Poro, Guguha, Kia and Allardyce.

Methods

Local community members were canvassed in order to identify respondents likely to have expert knowledge regarding the local marine environment. Based upon the author's two years of experience in the Solomon Islands as a Peace Corp volunteer, a list of 23 propositions was developed in order to measure marine ecological knowledge pertinent to the Solomon Islands. In one-on-one interviews, respondents (N= 30: 26 villagers, 4 AMCA Conservation Officers – COs) were asked to either "agree" or "disagree" to the 23 statements.[5] It was emphasised that there were no "right" or "wrong" answers and that individual opinions were being sought. Respondents were encouraged to volunteer additional information on the subject, and any supplemental information was recorded in field notes. All interviews were conducted in Pijin, the lingua franca of the Solomon Islands. Consensus analysis of responses supports the conclusion that all 30 respondents share a common cultural knowledge base.

Results

ANTHROPAC 4.92 (Borgatti 1996) software was used to analyze consensus data. Respondents recognised the truth/falseness of the propositions based upon their experiences with the marine environment. The analysis was run twice, once for the 26 respondents (villagers) answering about the marine environment around their villages and once for the four Conservation Officers (COs) regarding the marine environment of the Arnavon Marine Conservation Area (AMCA) — a marine protected area established in 1995. The Conservation Officers were separated in this anal-

5. In order to ensure comprehension of the task, respondents were given alternate phrasings with which to respond, such as "true" or "false", "correct" or "incorrect".

ysis because they responded to the ecological propositions in reference to the AMCA, whereas the other respondents answered in reference to the waters around their villages.

Analyses used both the matches and covariance calculations (Romney et al. 1986). Results were virtually the same. As a rule of thumb, consensus eigenvalue ratios above 3.00 demonstrate consensus among respondents (Borgatti 1996b: 44). Consensus analysis of marine ecological knowledge data based on the matches method resulted in eigenvalue ratios of 5.35 for the villagers and 13.66 for the COs, while analysis based upon the covariance method resulted in eigenvalue ratios of 5.57 for the villagers and 13.34 for the COs. Results verify that among respondents from both groups there exists a common body of marine ecological knowledge.

As noted, once it is determined that a consensus exists among respondents, analysis generates a set of "culturally correct" answers to the propositions in question. It is also possible to rank the respondents by comparing their answers to the culturally correct answer set, and to determine the average estimated knowledge of the respondents. Analysis shows the average estimated knowledge of the villagers to be 0.65. The Conservation Officers had an average estimated knowledge of 0.83. Table 1 shows the propositions used in the marine ecological knowledge survey and provides the culturally correct answers to each proposition, according to both respondent groups. The answer key for each group was identical regardless of the method (matches or covariance) used.

The probability that each of the above answers is the culturally correct answer, according to both respondent groups, is 100 per cent with the exception of question 11, where there was a 60 per cent probability that the culturally correct answer is True.

The culturally correct answers, according to the COs, differed only slightly. The COs answered differently on propositions 1, 4, 5, 7, 9, and 13, yet the probability that their answers are the culturally correct answers — according to "Conservation Officer culture" — is 100 per cent. Not surprisingly, these questions deal with populations of marine organisms, or in the case of number 9, the quality of coral reefs. Since the COs answered the propositions with respect to the Arnavon Marine

Table 1. **Marine ecological knowledge propositions and their culturally correct answers**

Yes/No marine ecological knowledge propositions:	Culturally correct answers	
	Villagers	COs
1. There are more turtles now than any time in the past ten years	**F**	**T**
2. Sea level has not risen over the past decade	F	F
3. Coral is an animal	T	T
4. Grouper populations have increased in the past decade	**F**	**T**
5. Parrotfish populations have declined in the last ten years	**T**	**F**
6. It is easiest to catch crayfish during the day	F	F
7. Beche de mer populations have decreased in the last ten years	**T**	**F**
8. The favourite food of leatherback turtles is jellyfish	T	T
9. The quality of the reef has declined over the past ten years due to anchor damage	**T**	**F**
10. Protected areas will help increase fish catches (outside the protected area)	T	T
11. Sea snakes are not poisonous	T	T
12. The moon does not affect the tides	F	F
13. Trochus populations have increased in the past ten years	**F**	**T**
14. Dolphins are not fish	T	T
15. Mangroves are important nursery habitats for fish	T	T
16. Intensive logging has degraded reefs	T	T
17. Giant clams eat fish	F	F
18. After hatching, male sea turtles never return to land	T	T
19. Salt-water crocodile populations have increased since the ban on hunting them	T	T
20. Parrotfish do not eat coral (stone)	F	F
21. Dugongs eat fish	F	F
22. In the past ten years, cyclones have damaged the coral reef	T	T
23. Sharks never attack people	F	F

Conservation Area, it is logical that they would respond by noting increases in marine species populations and state that the quality of the reef has not declined due to anchor damage (number 9). While all of the propositions are pertinent to the elicitation of cultural consensus regarding marine ecological knowledge, a select few are of particular significance to the concept of marine protected areas. The reasons given by villagers and COs for their (sometimes different) answers to these select marine ecological knowledge propositions include the following[6]:

Proposition 1: There are more turtles now than anytime in the past ten years.

Villagers: False
- "We hunt turtles. Before it was easy, now it's very hard…men eat the [turtle] eggs too."
- "People harvest them for consumption… very much for food. Even the eggs, if they find them they will eat them."
- "People now go to the nesting beaches. If people go there and start a village, they spoil the turtle's place."

Conservation Officers: True
- "[Turtles] were harvested [here] before, then we closed the area so there are many now."

Proposition 2: Sea level has not risen over the past decade.

Villagers and Conservation Officers (agree): False
- "[The sea] has risen a lot in the past ten years. It has caused much destruction of the shoreline…many places where we used to play before are gone now. Under the sea."
- "Now there are some parts that the sea didn't cover before that are covered."
- "Some of the islands that I visit used to be bigger. Now the sea can go inside the islands."

Proposition 4: Grouper populations have increased in the past decade.

Villagers: False
- "Our population was too big, so we take too many [grouper]".
- "We harvest them all the time so it can't increase."

Conservation Officers: True
- "Because I go fishing and now it's hard to miss. You can catch lots if you like." [Subsistence fishing for the Conservation Officers is allowed in the AMCA]

Proposition 5: Parrotfish populations have declined in the past ten years.

Villagers: True
- "Two reasons, one is the gillnet…actually three…the second is the use of a local poisonous leaf, the other is night diving. Before we didn't dive at night. It's easy to get [parrotfish] at night because they sleep on the reef."

Conservation Officers: False
- "I dive there [the AMCA] and there are a lot of parrotfish. And no one can net there now."

Proposition 7: Beche de mer populations have decreased in the last ten years.

Villagers: True
- "People with money come to buy them, so [we] always dive [for] them. If we aren't careful, they'll die out."
- "It is one marine product that [offers] big money, so people take them all the time."

Conservation Officers: False
- "They [populations] have gone up because we protect them."

Proposition 9: The quality of the reef has declined over the past ten years due to anchor damage.

Villagers: True
- "Lots of men [anchor on the reef] and it breaks the coral."
- "There are a lot of men who have an interest in fishing now [due to population increase]…children go fishing by themselves too." [resulting in more fishing pressure]

Conservation Officers: False
- Before this would have been true, but we've closed the area so the corals have recovered. – paraphrase
- "[The area] is closed and we [conservation officers] use mooring buoys."

Proposition 10: Protected areas will help increase fish catches.

Villagers and Conservation Officers (agree): True
- "Suppose we protect our [marine] areas, the fish and shellfish come back."
- "If they close an area, then the fish will go there. We can catch lots of fish close to a protected area."
- "A lot of fish will breed [in protected areas] then the fish will go outside [of the protected area]."

6. Responses were translated, by the lead author, from Solomon Islands Pijin

- "Fish have lots to eat in protected areas…and they won't stay in there all the time. They go in, out. You'll be lucky if you fish close to a protected area."

Proposition 13: Trochus populations have increased in the past ten years.

Villagers: False
- "If you dive these days to find trochus, you'll have a bit of a hard time…you can find them, but not a lot."
- "Over-harvesting. They take the small ones, no matter if it is undersized."
- "Only the small ones are left. Money has spoiled them."

Conservation Officers: True
- "We conduct surveys on [trochus]…you can see big ones, small ones all around now."

Proposition 15: Mangroves are important nursery habitats for fish.

Villagers and Conservation Officers (agree): True
- "Because the roots are a protective place where big fish can't attack small fish."
- "This is the place where any kind of fish from the sea will come to the mangroves to lay its eggs."
- "I dive there and see the young fish."

Proposition 16: Intensive logging has degraded reefs.

Villagers and Conservation Officers (agree): True
- "I strongly agree with that one. I see it here [due to a new logging operation]. The reef is dirty and the fish are gone."
- "When they cut down the trees it spoils the water. Then the water isn't pure. Eventually dust and dirt ruin the coral."
- "Because logging…heavy rains will take oil and rubbish and carry it to the sea."
- All COs agreed that logging is detrimental to reefs, but since there are no logging operations near the AMCA it did not apply.

In addition to determining both consensus and the culturally correct answers to the propositions, the agreement matrix produced by the ANTHROPAC software was submitted to nonmetric multidimensional (Euclidean) scaling in order to graphically represent the extent to which Solomon Island villagers' responses matched one another. Data used were based upon the agreement matrix of villagers using the matches method.

Looking at Figure 2, the positions of the 26 villagers (indicated with letters) are based on the similarity of the villagers' response patterns. The letters P, G, K, and A represent villagers from the communities of Poro, Guguha, Kia and Allardyce, respectively. The letter W represents the only respondent from the Western Province and not from the island of Santa Isabel. In addition, and as noted above, it is possible to determine the average estimated knowledge of the respondents, based upon the culturally correct answers, and therefore rank the respondents. The five highest ranking respondents are indicated by asterisks.

We reiterate our main finding that there is a cultural consensus among the 26 villagers regarding a single ecological reality. Collectively, these villagers share and respond to a common ecological knowledge base. Having said this, the issue of

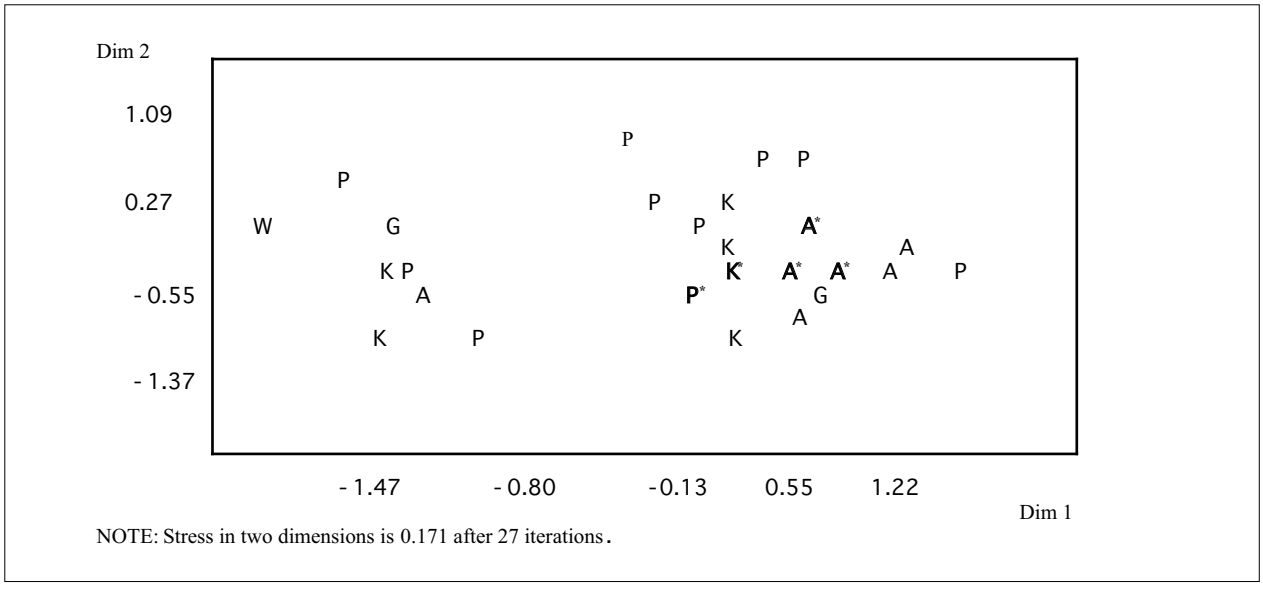

Figure 2. **Nonmetric multidimensional scaling of villagers**

individual differences can be considered. Generally, there is substantial overlap between communities suggesting that village of residence is not a key factor in shaping cognitions. This said, inspection of the scaling output shows that there is a loose grouping of respondents from Allardyce (A) clustered in the centre and right of the plot and another cluster of Kia (K) villagers in the centre. Respondents from Poro (P) are widely distributed. The single respondent from another province (W) is alone on the far left of the plot.

Discussion

In interpreting these results, in the context of marine protected area management in the Solomon Islands, we identify four findings with potential value to resource managers. First, we have determined that there is consensus, among villagers and among Conservation Officers, regarding marine ecological knowledge. This demonstrates a communication significance as one could therefore appeal to fishermen and managers, through their expert knowledge, to change behaviours regarding marine resource extraction. Second, results of some propositions highlight the status of stocks and are therefore important for their *resource assessment significance*. Third, consensus analysis allowed us to determine the "experts among experts" improving the *human resource significance* of each community by identifying those individuals who are particularly knowledgeable regarding the culturally correct marine ecology of their areas. Finally, our findings have *management significance* showing that the Arnavon Marine Conservation Area has been successful in increasing stocks of certain organisms.[7]

Conclusions

In this paper, we have discussed the merits of cultural consensus analysis technique and have employed the method in a Solomon Island application. Substantive results reveal that villagers (and separately, conservation officers) tap a single ecological knowledge base regarding the marine environment. We anticipate that our findings, taken together, can be useful in the context of marine protected area and fishery management.

Looking beyond the Solomon Islands, cultural consensus studies would seem to be useful to many marine protected area and fishery managers elsewhere. The method has great potential for the investigation of knowledge structures — both traditional and scientific — throughout the Pacific. We want to emphasise, however, that the method is equally pertinent to "basic" and "applied" science. Researchers can test theories about cultural universals in the realm of ethnoscience. Do, for example, fishermen and other residents of coastal communities in diverse societies think differently (that is, taxonomically) about aquatic fauna and flora? Do they think differently about changes in the marine environment that are linked to El Niño Southern Oscillation events and global warming?

Finally, cultural consensus analysis can support a diverse variety of management and conservation endeavours attuned to the ideal of sustainable development. Coastal tourism management, environmental management, and, of course, integrated coastal zone management applications come quickly to mind. All marine affairs practitioners should be familiar with this technique even if it is not in their personal methodological arsenal.

Acknowledgements

We would like to thank the wonderful people of the Solomon Islands who offered their time and insights to this project. The residents of Poro (and Putukora), Guguha, Kia and Allardyce were extremely charitable hosts and helped make the fieldwork very enjoyable. We must also thank The Nature Conservancy's Solomon Islands program for its assistance. The project would not have been completed without it. Finally, I must extend my deepest sympathies to the family of the late Michael Evo. His dedication to education in the Solomon Islands was commendable. He was a gracious host and a wonderful friend.

References

Akimichi T. 1978. The ecological aspect of Lau (Solomon Islands) ethnoichthyology. Journal of Polynesian Society 87:310–26.

Aswani S. 1997. Customary sea tenure and artisanal fishing in the Roviana and Vonavona Lagoons, Solomon Islands: The evolutionary ecology of marine resource utilization. PhD dissertation, University of Hawaii, Hawaii.

Aswani S. 1998. Patterns of marine harvest effort in southwestern New Georgia, Solomon Islands: Resource management or optimal foraging? Ocean and Coastal Management 40 (2–3):207–35.

Aswani S. and Hamilton R. 2004. The value of many small vs. few large marine protected areas in the Western Solomon Islands. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 16:3–14.

7. Importantly, villagers from Kia — the community closest to AMCA — were consistent in reporting higher fish catches along the protected area boundaries supporting the existence of a conservation "spillover" effect.

Batchelder W.H. and Romney A.K. 1988. Test theory without an answer key. Psychometrika 53 (1):71–92.

Borgatti S.P. 1996a. ANTHROPAC 4.92. (Analytic Technologies, Natick, MA).

Borgatti S.P. 1996b. ANTHROPAC 4.0 Methods Guide. Natick, MA: Analytic Technologies.

Boster J.S. and Johnson J.C. 1989. Form or function: A comparison of expert and novice judgments of similarity among fish. American Anthropologist 91:866–889.

Caukins D.D. 2001. Consensus, clines, and edges in Celtic culture. Cross-Cultural Research 35 (2):109–126.

Chick G. 1997. Cultural complexity: The concept and its measurement. *Cross-Cultural Research*, 31: 4: 275-307.

Christie P. in press. Marine protected areas as biological successes and social failures in Southeast Asia. American Fisheries Society Symposium.

Christie P. and White A.T. 1997. Trends in development of coastal area management in tropical countries: from central to community orientation. Coastal Management 25:155–181.

Christie P., White A. and Deguit E. 2002. Starting point or solution? Community-based marine protected areas in the Philippines. Journal of Environmental Management 66:441–454.

Clark J. and Murdoch J. 1997. Local knowledge and the precarious extension of scientific networks: a reflection on three case studies. Sociologia Ruralis 37(1):39–60.

D'Andrade R.G. 1995. The development of cognitive anthropology. New York: Cambridge University Press.

D'Andrade R.G. 2001. The sad story of anthropology 1950–1999. Cross-Cultural Research 34(3):219–232.

Foale S. 1997. Ownership and management of traditional Trochus fisheries at West Gela, Solomon islands. p. 266–272. In: Hancock D.A., Smith D.C., Beumer J.P. (eds). Developing and sustaining world fishery resources: the state of science and management. Second world fisheries congress, Brisbane. 1996, vol.2. Melbourne, Australia: CSIRO.

Garro L. 1986. Intracultural variation in folk medical knowledge. American Anthropologist 88:351–370.

Garro L. in press. Using consensus theory and schema theory in a three-community study of knowledge about diabetes. Ethnology [Paper originally presented at the Annual Meeting of the Society for Cross-Cultural Research, Santa Fe, NM; 1999].

Goodenough W.H. [1957] 1964. Cultural anthropology and linguistics. p. 36-39. In: Hymes D. (ed.). Language in culture and society: A reader in linguistics and anthropology. New York: Harper and Row. [reprinted from Garvin P.L. (ed.) Report of the seventh annual round table meeting on linguistics and language study. (Monograph Series on Languages and Linguistics, No. 9), Washington, D.C.: Georgetown University. 167–173]

Goodenough W.H. 1963. Cooperation and change: An anthropological approach to community development. New York: Russell Sage Foundation.

Hamilton R. and Walter R. 1999. Indigenous ecological knowledge and its role in fisheries research design: A case study from Roviana Lagoon, Western Province, Solomon Islands. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 11:13–25.

Honan M. and Harcombe D. 1997. Lonely Planet: Solomon Islands. 3rd ed. Lonely Planet Publications: Hawthorn, Australia.

Hviding E. 1988. Marine tenure and resource development in Marovo Lagoon, Solomon Islands: Traditional knowledge, use and management of marine resources, with implications for contemporary development. FFA Report No. 88. Honiara. Forum Fisheries Agency. 35 p.

Hviding E. 1989. Keeping the sea: aspects of marine tenure in Marovo Lagoon, Solomon Islands. p. 7–10. In: Ruddle K. and Johannes R.E. (eds.). Traditional marine resource management in the Pacific Basin: An anthology. Jakarta: UNESCO/Reg. Off. Sci. Technol. SE Asia. 410 p.

Hviding E. and Baines G.B.K. 1994. Community-based fisheries management, tradition and the challenges of development in Marovo, Solomon Islands. Development and Change 25:13–39.

Iannucci A.L. and Romney A.K. 1990. Consensus in the judgment of personality traits among friends and acquaintances. Journal of Quantitative Anthropology 4:279–295.

Jameson K. and Romney A.K. 1990. Consensus on semiotic models of alphabetic systems. Journal of Quantitative Anthropology 2:289–303.

Johannes R.E. 1977. Traditional law of the sea in Micronesia. Micronesia 13:121–27.

Johannes R.E. 1978. Traditional marine conservation methods in Oceania and their demise. Annual Review of Ecology and Systematics 9:349–64.

Johannes R.E. 1981. Words of the lagoon: Fishing and marine lore in the Palau district of Micronesia. Berkeley: University of California Press.

Johannes R.E. 1982. Traditional conservation methods and protected marine areas in Oceania. Ambio 11(5):258–61.

Johannes R.E. 2002. The renaissance of community-based marine resource management in Oceania. Annual Review of Ecological Systems 33:317–340.

Johannes R.E. and Hviding E. 2000. Traditional knowledge possessed by the fishers of Marovo Lagoon, Solomon Islands, concerning fish aggregating behaviour. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 5:8–15.

Johnson J.C. and Griffith D.C. 1996. Pollution, food safety, and the distribution of knowledge. Human Ecology 24(1):87–108.

Kelleher G. (ed.) 1999. Guidelines for marine protected areas. World Commission on Protected Areas Best Practice Protected Area Guidelines Series No. 3. IUCN–World Conservation Union.

Klauer C. and Batchelder W.H. 1996. Structural analysis of subjective categorical data. Psychometrika 61(2):199–240.

Lazarsfeld P.F. and Henry N.W. 1968. Latent structure analysis. Boston: Houghton Mifflin.

Lord F.M. and Novick M.R. 1968. Statistical theories of mental test scores. Reading, MA: Addison-Wesley.

Miller M.L., Kanko J., Bartram P., Marks J. and D. Brewer. 2004. Cultural consensus analysis and environmental anthropology: Yellowfin tuna fishery management in Hawaii. Cross-Cultural Research 38(3):289–314.

Moore R., Brodsgaard Mao T.-K., Miller M. L. and Dworkin S.F. 1997. Consensus analysis: Reliability, validity, and informant accuracy in use of American and Mandarin Chinese pain descriptors. Annals of Behavioral Medicine 19(3):295–300.

Nunnally J.C. 1978. Psychometric theory. New York: McGraw-Hill, New York.

Pollnac R.B., Crawford B.L. and Gorospe M.L.G. 2001. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. Ocean & Coastal Management 44(11-12):683–710.

Polunin N. 1984. Do traditional 'reserves' conserve? A view of Indonesia and New Guinea evidence. In: Ruddle K and Akimichi T. (eds). Maritime institutions in the Western Pacific. Senri Ethnological Studies 17. Osaka: National Museum of Ethnology.

Roberts C.M. and Hawkins J.P. 2000. Fully-protected marine reserves: a guide. WWF Endangered Seas Campaign. Washington D.C.

Romney A.K. and D'Andrade R.G. (eds.). 1964. Transcultural studies in cognition (Special Publication) American Anthropologist 66:3(Part 2).

Romney A.K., Batchelder W.H. and Weller S.C. 1987. Recent applications of cultural consensus theory. American Behavioral Scientist 31(2):163–177.

Romney A.K., Boyd J.P., Moore C.C., Batchelder W.H. and Brazil T.J. 1996. Culture as shared cognitive representation. Proceedings of the National Academy of Sciences 93:4699–4705.

Romney A.K., Weller S.C. and Batchelder W.H. 1986. Culture as consensus: A theory of culture and informant accuracy. American Anthropologist 88:313–338.

Ruddle K. 1993. The transmission of traditional ecological knowledge. p. 17–31. In: Dyer C.L. and Ingles J.T. (eds). Traditional ecological knowledge: Concepts and cases. Ottowa. International Development Research Center.

Ruddle K. 1994. A guide to the literature on traditional community-based fishery management in the Asia-Pacific tropics. FAO Fish. Circ. No. 869. 114 p.

Ruddle K., Hviding E. and Johannes R.E. 1992. Marine resources management in the context of customary tenure. Marine Resource Economics 7:249–73.

Ruttley H.L. 1987. Analysis of replies to a questionnaire on customary fishing rights in the Solomon Islands, Fisheries Law Advisory Programme, Western Pacific and South China Sea Region TCP/SOI/6601(A)FL/WPSCS/87/16, Rome: Food and Agriculture Organization of the United Nations.

Sabetian A. 2002. The importance of ethnographic knowledge to fishery research design and management in the South Pacific: A case study from Kolombangara island, Solomon Islands. Traditional Marine Resource Management and Knowledge Information Bulletin 14:22–34.

Spradley J.P. (ed.) 1972. Culture and cognition: Rules, maps, and plans. San Francisco: Chandler Publishing Company.

Sulu R., Hay C., Ramohia P. and Lam M. 2002. Status of Solomon Islands coral reefs. (in press).

Tyler S.A. (ed.). 1969. Cognitive anthropology. New York: Holt, Rinehart & Winston.

Weller S.C. and Baer R.D. 2001. Intra- and intercultural variation in the definition of five illnesses: AIDS, diabetes, the common cold, empacho, and mal de ojo. Cross-Cultural Research 35(2):201–226.

Weller S.C. and Romney A.K. 1988. Systematic data collection. Newbury Park, CA: Sage.

Weller S.C., Romney A.K. and Orr D.P. 1986. The myth of a sub-culture of corporal punishment. Human Organization 46:39–47.