Local Fisheries Knowledge:

The Application of Cultural Consensus Analysis to the Management and Development of Small-Scale Pelagic Fisheries

Project Final Report

John Kaneko, Paul Bartram,
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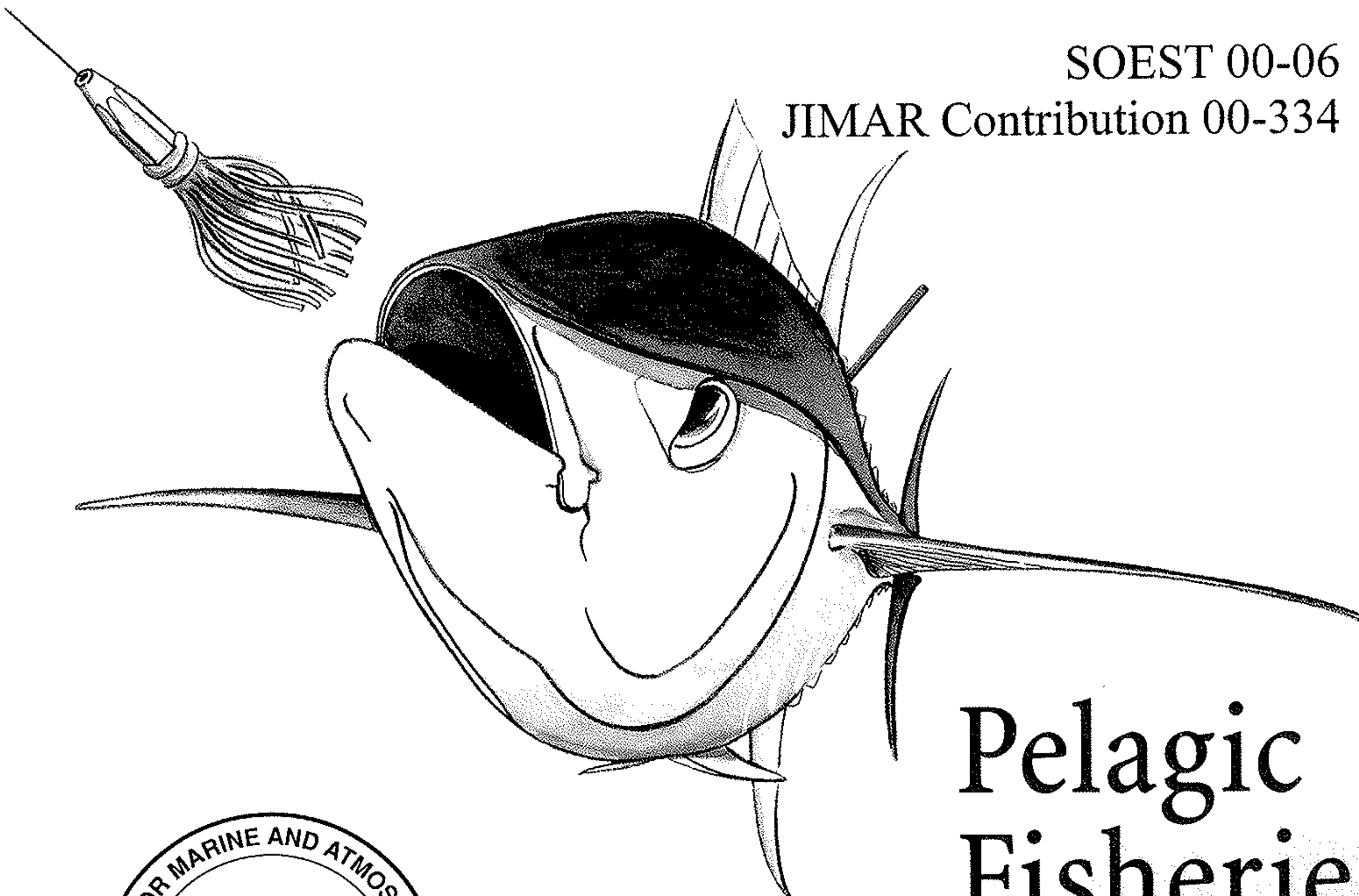
JIMAR Contribution 00-334



JOINT INSTITUTE FOR MARINE AND ATMOSPHERIC RESEARCH
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Pelagic Fisheries Research Program

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John Kaneko
Pacmar, Inc., Honolulu, HI

Paul Bartram
Akala Products, Inc., Honolulu, HI

Marc Miller
School of Marine Affairs
University of Washington, Seattle

Joe Marks
Kona, HI

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ABSTRACT

Effective natural resource management requires the best available knowledge about the biological, social, cultural, economic, and political factors that comprise a management system. Fishery managers base decision making on expert input from scientists, as well as the concerns of various stakeholders. Defining expert or stakeholder consensus views on fishery resources is critical to understanding how each group arrives at their particular assessments and opinions about management options. Cultural consensus analysis was evaluated as a quantitative means of eliciting and analyzing the consensus views on pelagic fisheries resources held by expert and stakeholder groups. The method is capable of determining if a group shares a consensus view on a set of resource questions. The method generates the consensus view (the answer key) through individual interviews without the need to convene the expert group and without knowing the answers ahead of time. Using this method, a group's consensus view can be determined without the politics inherent in a group consensus building process. The study investigated the use of cultural consensus analysis to determine the local resource knowledge held by fishermen. Information relevant to the management of Hawaii's yellowfin handline fishery, Hawaii's bigeye longline fishery, Guam's blue marlin troll fishery, and the management and development of Samoa's (Western and American) albacore alia longline fishery was elicited. The management and industry development implications of these consensus views are discussed. Cultural consensus analysis is recommended to fisheries managers as a potential management tool for use in resource issue scoping, problem assessment, formulation of research agenda and management options, conflict resolution, and selection of management policy.

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1. INTRODUCTION

Fisheries management is a dynamic balancing act involving multiple biological, environmental, social, and economic factors. Resource management decisions depend on the best available knowledge of the resource and, increasingly, on understanding the actions and motivations of the resource user groups and other stakeholders. In addition to scientific knowledge, fishery management decisions consider the opinions and concerns of divergent constituent groups. These include commercial and recreational fishers and conservation groups.

The Western Pacific Regional Fisheries Management Council (the Council) is charged with managing the pelagic fisheries resources within the exclusive economic zones around the US associated Pacific Islands. Diverse groups with a wide range of objectives, special knowledge, and practical experience participate in the Council's management process. The Council process seeks to manage on a consensual basis that balances the long-term conservation of fish stocks with the optimum economic utilization of the resources.

The inherent problem with consensual management is that the participating groups in each sector and level of the management process are separated by differing views of the natural system they are attempting to manage. Specifically, the groups differ in what they consider relevant information or data, how that information should be interpreted, and especially on how to respond (management actions) (Smith, 1990).

A methodology is proposed to assist managers to better define how participant groups view the resource under management. By understanding how the groups view nature, managers might be able to identify the basis for differing views and apply efforts to resolve conflicts by bridging the gap between groups in terms of the relevant data and its interpretation. If participating groups can be brought closer together by sharing a common view or understanding of the natural system being managed, the positions they eventually take on management issues may not be as extreme and polarized. This may enhance management capabilities and facilitate decision making.

1.1. Scientific resource knowledge

Fishery managers rely on the scientific community to provide them with expert opinions on the best available evidence or knowledge on which to formulate management policy. Fishery biologists study the fish to estimate population status, while fishery economists and sociologists study the fishers and other stakeholders and the factors that influence their actions.

Best available knowledge generally refers to the consensus interpretation of the current scientific evidence held by an expert group of scientists. Scientists formulate expert opinions based upon personal experience with controlled studies, statistical analysis, and research reported by other scientists. Publishing in peer reviewed journals is extremely important in validating scientific evidence, however, the results are always subject to the selective interpretation of individual scientists.

Scientists pursue answers to resource questions (hypotheses) and design objective studies to help statistically eliminate possible explanations for phenomena (null hypotheses). The scientific methods do not prove anything to be true, only that certain explanations are not true. Scientific knowledge is derived through a process of eliminating unsupportable hypotheses. What we consider scientific knowledge is based on probabilities of correct interpretation. In this way the best available knowledge depends on the interpretation of statistical probabilities or estimates of the truth. By asking for the best available knowledge on any subject, we are asking scientists what they believe to be true, based on their interpretation of the evidence.

1.2. Local resource knowledge

Local or traditional resource knowledge is achieved through the first-hand experience of fishers and the collective interaction and sharing of experience, theories, and ideas supported by evidence derived from personal involvement in fishing. The exchange of opinions held by individuals who are revered as peers or experts is extremely important in much the same way it is in the scientific community in arriving at conventional wisdom or consensus. These experts may consist of individuals known as good fishermen, old timers, elders but may also include scientists that fishers have access to through personal experience, popular media, and in some cases scientific literature. Local fisheries knowledge represents what fishers believe to be true about the resource based on their interpretation of the evidence.

1.3. Understanding the stakeholders

It is becoming widely accepted that sound management of natural resources, including fisheries, requires greater attention to resource users (Jentoft and McCay, 1995; McCay and Jentoft, 1996; Weeks, 1995). While there is recognition of the need to engage resource users in the management process, most often users are only the focus of management options and are not recognized as a source of potentially valuable resource knowledge. Although fishers are routinely consulted in the formulation of fishery management policy, they are more likely to be treated as an interest group rather than a source of resource information.

Fishers' knowledge of marine resources (variously termed local knowledge, traditional knowledge, folk knowledge, working knowledge, or indigenous knowledge) is often overlooked (Ruddle, 1995). The potential value of users' knowledge to enhance the understanding of the biology of managed species has become more widely recognized, yet little progress has been made toward integrating this information into contemporary resource management systems (Weeks, 1995; Wilson and McCay, 1998). Evaluating the users' knowledge or beliefs helps to define what various user groups believe and what beliefs form the basis of their particular positions on resource management.

1.4. Fishery management and conflict resolution

The Council process engages a broad cross-section of experts and constituents including fishery scientists, commercial and recreational fishers, and conservation interests. The Council's management decisions are arrived at through a political process that takes into account available evidence, public testimony, and consensus building within the Council's voting members. Understanding how constituent and expert groups view the resource, and the basis of that perspective, can go a long way towards helping fishery managers to dissect the nature of resource conflicts, seek actions to resolve conflicts and reach rational policy decisions.

Much of the polarization and conflict over fishery management policy issues stems from differences in how individuals and stakeholder groups view the fishery resource and its status. Understanding what constituents believe about resource issues may be as important as understanding the current scientific consensus in fisheries management. Although we place the major emphasis on scientifically derived knowledge or information, conflict between resource user groups often results from a difference in the information and/or experience base and the interpretation of the information on which beliefs held by user groups are formed. Individuals or groups may also make interpretations of selective data sources that tend to support a specific set of beliefs. In this way it may be extremely valuable for fisheries managers to analyze what each group "believes" (including scientists and stakeholders) as an early step in preparing assessments and policy options, before the debate and posturing begins.

1.5. The Local Fisheries Knowledge Project

This report presents the results of the Local Fisheries Knowledge Project that explored a methodology for eliciting and analyzing local fisheries resource knowledge held by commercial fishers as a means of understanding what beliefs form the basis of their view of the fishery resources they utilize. The project focused on commercial fishermen involved in pelagic fisheries in Hawaii, American and Western Samoa, and Guam within the context of fisheries management and fishery development issues.

1.6. Anticipated benefits

The fisheries management process stands to be enhanced and strengthened by efforts to engage fishers (and other stakeholders) through a mechanism by which their expert beliefs can be elicited and analyzed. With a greater understanding of constituent groups and the consensus of their beliefs, fishery managers may be better equipped to anticipate conflict over management options. They can also address specific resource questions that are at the root of the polarization of stakeholders, scientists, and managers on critical management issues.

Efforts to elicit and evaluate local fisheries knowledge can provide mutual benefits for fisheries managers, fisheries scientists, and fishers as follows.

1.7. Fishery managers

- Understand how fishers' view the resource—what are the premises, beliefs, and assumptions about the resource that shape their perspective.
- Determine how fishers' perspective compares with fishery scientists (or other groups).
- Take advantage of a supplemental source of resource information.
- Improve credibility of the management system, compliance with regulations, and quality of catch reports.

1.8. Fisheries scientists

- Fishers' insights may help to facilitate hypothesis formation about fisheries dynamics.
- Refinement of theories on resource issues through expert insight from fishers.
- Enhanced research agenda and possibilities for collaborative research with fishers.
- Increased understanding of fishers' perspective on the resource.
- Improved communication, outreach, and extension with fishers.
- Improved cooperation from fishers with data collection.

1.9. Fishers*

- More actively engaged in the management process by providing resource knowledge input.
- Improved understanding of the scientific basis of fishery management.
- Increased recognition and respect as a complementary source of expert opinion.

*Note: All fishers involved with this project were men. The term "fishermen" will be used from here on in this report with all due respect for women fishers in other fisheries.

2. METHODS

2.1. Fishery management context

Fisheries under the management of the Western Pacific Regional Fisheries Management Council were screened as candidates for project efforts. Several fisheries, gear types, and locations were selected for the study (Table 1) in order to evaluate the users' consensus view of the resources and to demonstrate the potential value of local fisheries knowledge.

Table 1. Local Fisheries Knowledge Project sites, fisheries, and fishers

Pelagic species	Location	Source of local fisheries knowledge	Fisheries management context
Yellowfin tuna	Island of Hawaii	Handline fishermen	Yellowfin tuna management
Albacore tuna	Am. Samoa and Samoa	Small-scale longline fishermen (*alia* fleet)	Small-scale fisheries development and management
Blue marlin	Guam	Troll fishermen	Blue marlin management
Bigeye tuna	Oahu, Hawaii	Longline fishermen	Bigeye tuna management

2.1.1. Yellowfin tuna resource knowledge

Handline fishermen from the island of Hawaii were selected because it was expected that these fishermen might provide long-term, in-depth knowledge of the yellowfin tuna (*Thunnus albacares*) resource near the islands, natural fish aggregations (ahi koa) and the effects of fish aggregating devices (FADs) on fish abundance. Yellowfin tuna are extremely important to commercial longline, handline, and troll fleets as well as numerous recreational and subsistence fishermen in Hawaii. Effective management depends on knowledge of yellowfin population status, movements, and aggregations. In addition, some of the same handline fishermen were engaged in the handline fishery at the Cross Seamount where numerous small bigeye tuna are caught. Some fishermen have expressed concerns about the impact of fishing at the Cross Seamount and the potential for gear conflicts between longliners and handliners.

2.1.2. Albacore tuna resource knowledge

The rapid expansion of the small-scale longline albacore (*Thunnus alalunga*) fishery in Samoa and subsequently in American Samoa prompted the team to investigate the extent of albacore resource knowledge held by Samoan fishermen. The aim of the interviews was to determine if there was long-term and in-depth knowledge about the albacore resource that might help managers with industry development planning, promotion, forecasting, and future resource management.

2.1.3. Blue marlin resource knowledge

The Guam troll fishery for Pacific blue marlin (*Makaira nigricans*) is very important to the local commercial and recreational trollers. Expert fishermen in Guam were selected for interviews in order to focus attention on the blue marlin resource. Guam also has an important fresh tuna transshipment industry that services foreign flag longline vessels fishing in equatorial waters. Troll fishermen were asked their beliefs about the blue marlin resource in the context of possible management concerns about foreign tuna longliners fishing in the region and transshipping through the Port of Guam.

2.1.4. Bigeye tuna resource knowledge

Longline fishermen based on the island of Oahu in Hawaii were interviewed to determine their beliefs about the bigeye tuna (*Thunnus obesus*) resource. The general lack of knowledge about bigeye tuna has led fisheries scientists to focus more attention on this species. It was anticipated that long-term Hawaii longline fishermen who historically have targeted bigeye might have strong beliefs about the bigeye resource that could be of value to scientists and managers.

2.2. General description of cultural consensus analysis

A quantitative method known as cultural consensus analysis, was selected to evaluate local fisheries knowledge. Cultural consensus analysis is derived from test theory and evaluates the responses of informants to a series of belief statements. Cultural consensus analysis was used in this study to quantify, evaluate, and compare constituents' beliefs on resource issues. A list of belief statements or propositions was prepared specifically to develop a picture of how constituents view their environment, the fishery resource, and their orientation to the fisheries resources they utilize.

Resource questions or belief statements were formatted to be answered I believe or do not believe, true or false, and agree or disagree. The statements written in this manner allow for quantitative methods where a 1 is assigned when a respondent believed the statement and a 0 is assigned when they did not believe the statement. In this way each respondent within a group, has a sequence of 1's and 0's to the list of belief statements that can be analyzed quantitatively.

Rather than being a survey that might simply tally the responses of a representative sample of informants, consensus analysis allows for a narrow focus on insights from experts. Cultural consensus analysis is capable of deriving the consensus of a group of expert respondents based on the results of individual, face-to-face interviews. The consensus derived through individual interviews differs from one achieved through discussion and debate within a group, which is ultimately a political process. Consensus analysis is a potentially powerful tool in that the group consensus derived is not a simple matter of the majority of responses, but ranks respondents by expertise or competency against the group's consensus and determines a weighted value of their individual responses.

Essentially, cultural consensus analysis allows researchers to answer three basic types of questions.

- Do respondents share a single knowledge base? Is there a single consensus or are there multiple versions?
- If the respondents share a consensus view, what are the culturally correct answers to the resource propositions?
- If there is a consensus, are there particular issues (beliefs) on which individuals or subgroups disagree?

Cultural consensus analysis has great potential value and is capable of the following.

- Evaluating the expertise or cultural competence of individual respondents in contributing to a shared pool of information.
- Rapidly synthesizing expert fishermen's beliefs and evaluating the degree of consensus.
- Identifying which beliefs participant groups (i.e., fishermen and scientists) agree on and those that they interpret differently.

Consensus analysis generates an answer key that reflects the consensus of the expert group on a series of resource questions or propositions. The analysis allows for further scrutiny of each resource proposition and generates the probability of having selected the culturally correct answer. This analysis also allows for the evaluation of the level of agreement or the strength of consensus between potential subgroups within the expert group (i.e., fishermen versus scientists, handline fishermen versus longline fishermen, etc.).

Consensus analysis has great potential value as a management tool to assist resource managers and policymakers in determining the degree to which interest groups agree or disagree on basic resource knowledge or beliefs that form the foundation of their perspectives on resource management issues.

2.3. Cultural consensus analysis methodology

The basis for cultural consensus analysis stems from mathematical anthropology and psychometrics (Romney 1989; Romney, et al., 1986; Romney, et al., 1987; Romney, et al., 1996). In essence, the technique is capable of simultaneously estimating the cultural competence or knowledge of each informant and produces an estimate of the correct answer to each resource question or proposition without needing to know the answers in advance. In this way, the analysis determines what the group believes to be true and not absolute truths.

2.3.1. Assumptions of the cultural consensus model

Assumption 1. *Common truth.* The assumption is made that a single fixed answer key exists for all respondents. This essentially means that all respondents belong to one culture.

Assumption 2. *Local independence.* It is assumed that questions or answers given by other respondents do not shape the respondents' answers to questions.

Assumption 3. *Homogeneity of items.* It is assumed that a respondent has a fixed competence across all questions.

2.3.2. Model outputs

Competency scores. This is a measure of how well the individual respondent agrees with the other respondents. Competency scores are used to derive the answer key (consensus). The competency score is essentially a measure of the reliability of the individual respondent's set of responses to the resource propositions as an estimate of the expert group's answer key or consensus. The technique allows for determining if individuals should be included in the selected group of experts.

Answer key. After each respondent has been given a competency score, cultural consensus analysis proceeds with the generation of the correct answers. The estimated answer key to the series of resource propositions (belief statements) represents the group's consensus and is generated by input from individual expert respondents. This process relies on Bayesian strategy as described by Romney, et al., (1986).

Similarity matrix. The third output is a square matrix displaying the similarities of answers for all pairs of respondents. A similarity matrix displays the degree to which pairs of respondents agree by presenting the correlations for all pairs of respondents. This matrix can be further analyzed using multi-dimensional scaling, hierarchical clustering, and related techniques of analysis (Shephard, et al., 1972, Weller and Romney, 1988).

2.3.3. Criteria for consensus

Response matrices should be analyzed by two approaches—the matches and covariance techniques. This allows for determining if the input response data reveal a cultural consensus (or lack of consensus). The criteria for cultural consensus include

- mean competence scores generated by the matches approach roughly equals that of the covariance approach;
- the competency score vector generated by the matches approach correlates with that of the covariance approach; and
- the ratio of the first to the second eigenvalues is approximately 3 or greater for each method (Romney, et al., 1986).

2.3.4. Sample size requirements

Cultural consensus analysis allows us to reliably generate an answer key by the aggregation of cultural knowledge based on relatively small samples of experts (down to four respondents). High levels of statistical confidence can be achieved with small sample sizes when the average competency score of respondents exceeds 0.5. Batchelder and Romney (1988) and Weller and Romney (1988) present a useful table showing the minimum number of respondents required to be certain of the answers to between 80 and 99% of the questions at standard levels of confidence (0.90, 0.95, 0.99, 0.999).

2.4. Analytical sequence

2.4.1. Developing the resource belief statements

The team drafted a series of belief statements for each of the four fisheries and project sites selected for this research effort. These statements were aimed at eliciting input on a range of fisheries resource knowledge pertinent to the management and/or development of these particular fisheries. This included knowledge or beliefs about population status, fish aggregation and movements, reproduction, fishing impacts, and sustainability of the resource.

The scope of the belief statements was designed to address some of the important pieces of information that form the basis of how respondents view the resource and are necessary for fishery managers to make informed fishery management decisions. In addition, the statements were meant to be provocative and to stimulate the experts to provide additional insight which might prove valuable in developing research questions (hypotheses), research agenda, confirming findings and/or focusing management activities.

2.4.2. Selection of experts and the interview process

At each of the four project sites, the team utilized its professional network of fishermen, fisheries scientists, and managers to first confirm the potential scope of pelagic fisheries resource management issues and then to assist in identifying long-term expert fishermen to be targeted for interviews. Initial pre-qualification as an expert fisherman was a minimum of 10 years in the fishery (except in the Samoa fishery).

A team of two project researchers conducted face-to-face interviews with individuals identified as experts. Respondents were asked whether or not they believed a series of resource propositions to be true or false. Respondents were instructed to equate true with believe, tend to believe, agree, and correct. It was stressed that the study was focused on local fisheries knowledge or their beliefs, rather than on absolute truth.

2.4.3. Analysis

Consensus analysis produces output expressing inter-respondent similarity that is then submitted for multi-dimensional scaling analysis and other complementary analyses (ANTHROPAC 4.92 software by Borgatti, 1996).

2.4.4. Fishermen's expert insights

The series of belief statements or propositions created a framework for respondents to offer supplemental inputs, elaboration, and explanations. Respondents were encouraged to provide resource questions and theories that they might have regarding the pelagic fisheries resources, fishing industry operations, and management needs.

3. RESULTS

3.1. Results: Yellowfin tuna knowledge held by Hawaii handline fishermen and pelagic fisheries scientists

3.1.1. Fishery management context

This effort was focused on the nearshore handline fishery on the island of Hawaii, which targets yellowfin tuna, and the more recent fishing efforts on bigeye tuna associated with offshore seamounts. Fishery management issues include the potential for gear conflicts, fleet interactions, and efforts to control these by area closures and limited entry programs. The information gathered reflected the opinions or beliefs of fishermen on tuna population structure, movement and aggregation behavior, stock condition, fishing pressure, etc.—all valuable information for scientists and fisheries managers.

3.1.2. Expert fishermen

Resource knowledge held by a group of expert tuna handline fishermen was elicited and analyzed. The team identified commercial tuna handline fishermen from the island of Hawaii with a minimum of 15 years in the fishery. A set of belief statements about the tuna resource was presented to the fishermen during face-to-face interviews. The interview process typically took one hour but some fishermen required two hours to finish.

Thirty-five handline fishermen were interviewed by the team on the island of Hawaii in Hilo, Pohoiki, Kona and Milolii. The minimum number of years in the fishery was 16 and the maximum was 60. The average was 27.5 years and the cumulative number of years represented was 965 years of fishing experience. Within this group, 24 fishermen fished primarily nearshore for yellowfin and 11 also fished for bigeye at offshore seamounts.

3.1.3. Expert scientists

The same set of questions was later asked of Hawaii-based pelagic fisheries research scientists who study tuna. This made it possible to compare how fishermen and scientists view the same tuna resource.

A select group of pelagic fisheries research scientists was drawn from the National Marine Fisheries Service, the University of Hawaii, the State of Hawaii, Department of Aquatic Resources, and the Western Pacific Regional Fisheries Management Council for expert opinions on the yellowfin resource. Twenty-three research scientists were interviewed. Scientists were selected for their knowledge of tuna fisheries in Hawaii and involvement in pelagic fisheries research. Each scientist was in some way involved in scientific research aimed at providing the basis for pelagic fisheries management in the western Pacific and, in particular, Hawaii-based tuna fisheries.

3.1.4. Cultural consensus analysis

This initial effort revealed an analytical constraint. Within the group of 58 expert fishermen and scientists interviewed, not all respondents had strong beliefs on at least 90% of the resource belief statements. For this reason the number of individuals included in the expert group for consensus analysis was reduced to 23 fishermen and 7 scientists that answered at least 90% of the resource statements.

The initial analysis also exposed questions that less than 90% of the selected expert group were able to answer with confidence. These questions were eliminated from the analysis resulting in the refined list of belief statements. The resulting set of statements was concentrated on the yellowfin resource.

There is also value in identifying the resource questions for which these experts did not have firm beliefs. In this way, consensus analysis not only generates and analyzes the expert consensus, but also culls the questions that are not components of the selected realm of resource knowledge. For both fishermen and scientists groups, knowledge about yellowfin resource propositions was far greater (more complete set of answers, more confident, more willing to commit to belief statements) than for the series of questions asked about bigeye tuna or other species. This group of experts was not able to give complete sets of answers and considered information (experience, beliefs, or fisheries data) to be generally lacking or inadequate regarding bigeye tuna and blue marlin. This eventually led the team to focus efforts on a group of longline fishermen in Hawaii that should have stronger beliefs about bigeye tuna from long-term, first-hand experience (presented in Section 3.4).

Other questions deemed to have been nested or linked were also omitted following the prerequisite for the cultural consensus model. This explains why the question numbers are not in a complete number sequence in Table 2. This initial effort to apply cultural consensus analysis revealed issues of question formatting and the need for eliciting more complete responses when possible. These lessons were applied to the subsequent project efforts in drafting the resource belief statements.

3.1.4.1. Were these individuals experts (competency scores)?
Yes. The final group of fishermen and pelagic research scientists were determined to be experts based on individual competency scores derived from the subset of belief statements focused on yellowfin tuna.

Matches method: Using the matches method to measure agreement among respondents, the ratio of the first to the second eigenvalue was 3.636. This indicated that the group shared a body of knowledge. The prerequisite for applying consensus analysis is an eigenvalue ratio of greater than 3.00. The average competency score for the group was 0.599 (s.d. 0.148, range 0.25 to 0.87). The cultural consensus model can be applied when the average competency score is equal to or greater than 0.50.

Covariance method: Using the covariance method, the eigenvalue ratio was 2.70 and the mean competency score was 0.47. This indicated that the matches method produced a better fit and the results of the matches method were used for further analysis.

3.1.4.2. Is there consensus on the set of resource propositions (answer key)?
Yes. Consensus analysis of yellowfin tuna knowledge shows that fishermen and scientists share a single cultural knowledge base or consensus view (Table 2). For each resource statement, the culturally "correct" answer is bolded. The numbers of respondents answering true and false are reported. The probability of identifying the correct answer to each proposition through consensus analysis is also calculated. For most questions, the probability is greater than 0.99.

Table 2. Hawaii yellowfin fishery resource propositions and consensus

No.	Belief statement about the yellowfin resource	Consensus	
3.	Yellowfin caught in Hawaii are a mix of resident and migratory fish.	**True❶** 26	False 5
13.	Yellowfin are caught in Hawaii mostly in the summer because they migrate to other areas during the winter.	**True** 31	False 0
19a.	Most of the yellowfin catch in Hawaii is concentrated around the 1,000-fathom contour.	**True** 18	False 13
22.	The abundance of yellowfin in Hawaii depends on how much fishing occurs in and around the 200-mile zone.	True 9	**False** 22
23.	The abundance of yellowfin in Hawaii depends on how much fishing is done before the fish migrate near Hawaii.	**True** 30	False 1
26.	The abundance of yellowfin in Hawaii depends on the availability of food (prey) in Hawaii waters.	**True** 31	False 0
27.	The cycles of high and low tuna abundance in Hawaii depend on variation in ocean temperature and currents.	**True** 31	False 0
28.	Variation in tuna (and marlin) abundance in Hawaii depends on variation in fish abundance oceanwide.	**True** 27	False 4
29.	Yellowfin catch is strongly affected by the full moon.	**True** 25	False 6
33.	FADs divert tuna away from natural *ahi koa.*	**True** 25	False 6
34.	The overall abundance of tuna around Hawaii is the same with or without FADs.	**True** 25	False 6
35.	Tuna abundance around natural *ahi koa* has declined because of overfishing.	**True** 16	False 15
38.	The yellowfin resource in Hawaii is being overfished (present yields not sustainable).	True 11	**False** 20
39.	The yellowfin resource in central and western Pacific is being overfished (present yields are not sustainable).	**True** 21	False 10
40.	The yellowfin caught in Hawaii are getting smaller.	**True** 23	False 8
47.	The yellowfin resource in Hawaii is not as abundant as 10 years ago.	**True** 25	False 6
50.	Heavy fishing by existing Hawaii boats alone could deplete tuna abundance in Hawaii.	True 7	**False** 24
52.	Heavy fishing on small tuna at seamounts, weather buoys, and FADs will cause a decline in future abundance of large tuna in Hawaii.	**True** 20	False 11
54.	Heavy fishing on large tuna and large marlins in Hawaii will cause a decline in the future abundance of these fish in Hawaii.	**True** 20	False 11
55.	Heavy fishing in any one area can cause localized depletion (long term).	True 10	**False** 21

❶ = the bolded answer represents the consensus; probability is greater than 0.99

Although there is evidence of a strong consensus (P>0.99) on all of the resource statements, further analysis of the responses reveals how scientists and fishermen as subgroups compared in contributing to the consensus on key issues of tuna distribution and resource sustainability. The majority of scientists disagreed with the consensus on the following five resource questions.

- Fishermen (15 out of 24) believed that most of the yellowfin are caught along the 1,000 fathom contour while scientists (4 out of 7) did not (question 19a).

- Fishermen (13 out of 24) believed that tuna abundance around *ahi koa* has declined because of overfishing while scientists (4 out of 7) did not (question 35).

- Fishermen (20 out of 24) believed that yellowfin tuna in the central and western Pacific are currently being overfished while scientists (6 out of 7) did not (question 39).

- Fishermen (19 out of 24) believed that heavy fishing at offshore seamounts and FADs will cause a decline in the future abundance of large tuna in Hawaii. Scientists (6 out of 7) did not believe this is possible (question 52). This supports the need for studies on the significance of seamounts to the recruitment of large tuna accessible to Hawaii's handline and longline fleets.

- Fishermen (17 out of 24) believed that heavy fishing of large tuna and marlin in Hawaii will cause a decline in future abundance of these fish in Hawaii (question 54). Scientists (4 out of 7) believed that because Hawaii's total tuna catch is a relatively small portion of the total Pacific tuna catch, that landings in Hawaii will not likely affect future availability because of recruitment from the greater ocean-wide population.

These 5 statements reveal how consensus analysis can with confidence (P>0.99) determine the consensus opinion but at the same time be used to determine how subgroupings responded and might be divided on specific resource issues.

3.1.4.3. How much agreement is there among experts (similarity matrix)?

A similarity matrix generated by the consensus analysis indicating the proportion of matches (corrected for guessing) between each pair of respondents was submitted to non-metric multidimensional scaling (MDS) to represent graphically the similarity of respondents in terms of their response patterns. Figure 1 shows the first two dimensions of the MDS solution (stress = 0.163 achieved after 19 iterations).

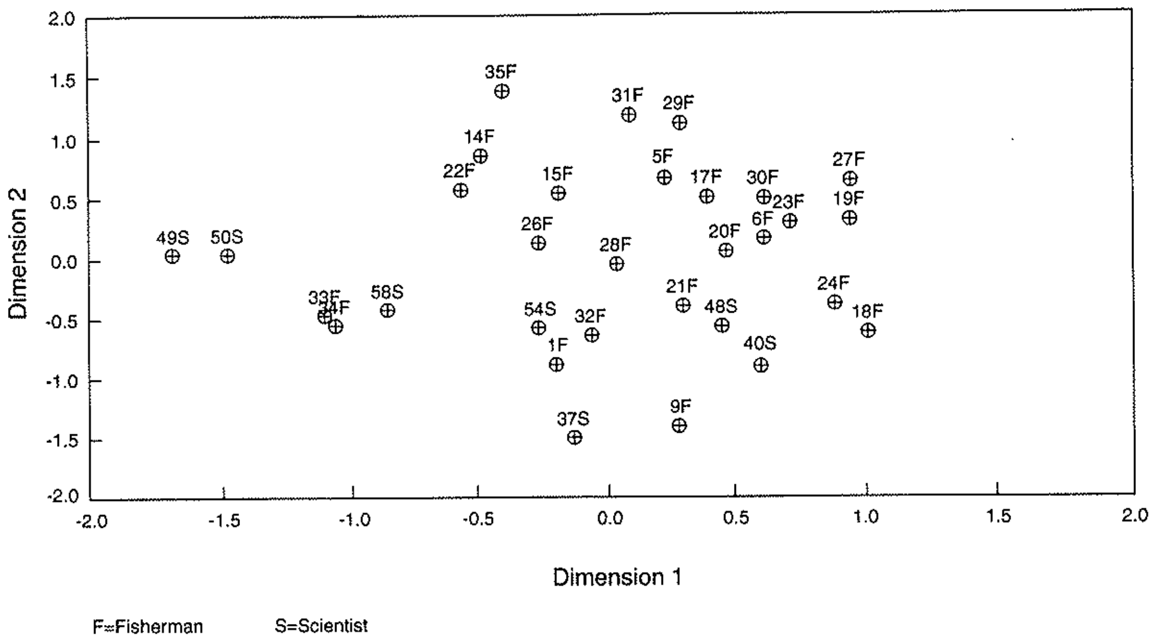

Figure 1. Hawaii Yellowfin Knowledge Similarity matrix

The numbers plotted represent individual respondents. The figure reveals that the fishermen are dispersed with no conspicuous clustering. The scientists interviewed are loosely clustered in the lower left portion of the matrix. This suggests that while the fishermen and scientists generally share a single perspective on the body of yellowfin tuna resource propositions, they may tend be in less agreement on certain resource beliefs. This finding has been supported by the results of the analysis of responses to individual resource propositions where the two groups disagreed.

3.1.5. Management implications

The handline fishery centered on the island of Hawaii has traditionally targeted yellowfin tuna. Much of the fishing activity revolved around natural fish aggregations known as ahi koa. Knowledge of ahi koa is of great interest in that it has been developed, evolved, and shared among local fishermen for many years (even generations). This knowledge is important in the context of the management of Hawaii's pelagic fishing fleets that target yellowfin and managing potential gear interactions between longline, handline, and troll fishermen.

The investigation of local fisheries knowledge about yellowfin tuna provided an opportunity to apply cultural consensus analysis to a situation to determine if two constituent groups share a common view of the resource. In general, both fishermen and pelagic fisheries scientists share a common base of knowledge or beliefs about yellowfin.

There are several issues on which these two groups are in disagreement. Further consideration of these particular issues revealed that the probable source of this discrepancy is a matter of perspective. Fishermen, for the most part, shared a detailed knowledge base regarding the yellowfin resource within the range of their vessels. Island handline fishermen tended to have a local perspective about pelagic resources with a strong experience-based consensus. This group does not share the same stock-wide perspective that tends to form the research-based consensus of pelagic fisheries scientists.

Fisheries scientists tended to share an oceanic-scale perspective on the yellowfin tuna population with less emphasis on the local nearshore fishery. This explains why fishermen and scientists could disagree on such major issues as local overfishing, overfishing by foreign fleets outside of the range of handliners, and the potential for overfishing by the existing fleets in the Pacific.

Both groups believe that yellowfin caught in Hawaii are a mixture of resident and wide-ranging fish. A mixed population assumes the existence of a resident yellowfin subpopulation. The resource information needed for the management of resident yellowfin subpopulations is likely to differ from information needed for managing wide-ranging yellowfin populations.

In contrast to yellowfin knowledge, fishermen did not have strong beliefs about the bigeye tuna resource due to the relative lack of first-hand experience and limited awareness of available scientific literature. Only a few of the fishermen were willing to make belief statements regarding bigeye tuna. Scientists also lacked a strong set of beliefs regarding the bigeye tuna resource and reported that more research was needed in order to answer some of the questions posed.

These findings should be of interest to fishery managers faced with conservation decisions and to scientists and fishermen in the formulation of research agenda needed to support fisheries management objectives.

3.1.6. Fishermen's expert insights

Fishermen were encouraged to provide additional insights, observations, and theories about the tuna populations and environmental relationships. These are presented in no particular order or ranking. These insights are presented so that potentially valuable theories and observations are not discarded simply because the team of researchers did not anticipate the question or the belief did not have widespread support from the other experts.

- Some fishermen believe that there used to be more resident yellowfin in Hawaii. The concept of resident yellowfin stems from the year-round availability of yellowfin tuna at ahi koa maintained and fished by these fishermen.
- Some fishermen believe that Hawaii's resident yellowfin population has been decimated and no longer exists.
- Some fishermen believe that FADs have disrupted the productivity of natural ahi koa by changing local tuna movement routes and aggregations.
- Some fishermen describe ahi koa as subsurface features that tend to aggregate tuna. They believe that ahi koa are effective tuna aggregators due to the relationship between currents, availability of forage species, and a critical maintenance component.

- Some fishermen believe that ahi koa must be maintained by regular feeding (chumming) and training of tuna to recognize ahi koa as viable foraging locations. Fishermen attribute some of the decline of fish availability at the ahi koa to the lack of proper maintenance by younger fishermen or new comers to the fishery, and the use of improper feed materials.

- Some fishermen believe that shifts in ocean currents off the Kona coast of the island of Hawaii may be responsible for part of the disruption of ahi koa. Fishermen report that for decades, the prevailing currents in particular areas offshore of Kona were consistent and predictable. Since 1985, they observed that the current is no longer predictable and must be determined each day to plan for fishing drift patterns and orientation to ahi koa. Prior to 1985, the current ran north on a much more constant basis and was associated with colder water temperature and higher catch rates at ahi koa.

- Some fishermen believe that ahi koa can be located near most Pacific Islands and that with time, experienced koa fishermen should be able to identify these locations and develop productive tuna fishing locations.

- Some fishermen believe that yellowfin morphology is indicative of the types of tuna populations. They believe that an elongated body shape and exaggerated features (long second dorsal and anal fins) are characteristic of far traveling, wide-ranging schools versus fish that tend to be less traveled and stay near the islands.

- Some fishermen report that it is possible to predict the productivity of the yellowfin tuna season in Hawaii by observing the morphology of the first yellowfin tuna caught in the summer run.

- Some fishermen believe that the intensity of the mango and coffee flowering is a reliable predictor of the productivity of the summer yellowfin run.

- Some fishermen believe that 2 years following an excellent year for the opelu (mackerel scad, *Decapterus pinnulatus*) fishery, will be an excellent year for yellowfin tuna in Hawaii.

3.1.7. Conclusion

Interviews of yellowfin fishermen from the island of Hawaii were the first attempt by the team to apply the cultural consensus analysis methods to local fisheries knowledge. This initial effort can be viewed as a beginning, rather than an end product. However, the findings identify a basic difference in perspective that characterizes Hawaii handline fishermen and pelagic fisheries scientists and helps to explain why they differed so strongly on certain resource issues. At first, this may at first appear to be a trivial finding. However, in practice, many of the critical fishery management issues facing the Hawaii yellowfin tuna fishery involve issues which require a knowledge of tuna population movements and aggregations within nearshore waters and not stockwide issues in international waters. The consensus that yellowfin tuna caught in Hawaii's handline fishery are a mixture of resident and wide-ranging fish indicates a need to include both nearshore (localized) and Pacific-wide tuna population perspectives when developing fishery research agenda and management policy.

This also identifies an information gap and a basic need to disseminate information on larger scale fishery issues to local fishermen. Efforts to share scientific tuna population assessments with fishermen are important. Ideally this information would be summarized and then presented in a format easily accessible to fishermen. By sharing this information, the apparent information gap and difference in perspectives between handline fishermen and scientists might be reduced.

This led the team to draft a summary of information on the current condition of the Pacific-wide tuna fishery as well as the condition of tuna fisheries in other oceans. This draft document has been submitted to the Pelagic Fisheries Research Program for possible distribution to fishermen.

3.2. Results: Albacore tuna resource knowledge held by Samoa small-scale longline fishermen

3.2.1. Fishery management context

A small-scale longline fishery for albacore has undergone remarkable growth in recent years in Samoa and American Samoa. The Samoa component of the study was aimed at determining if the local fisheries knowledge held by a group of Samoan fishermen about the albacore resource was well developed and might serve as a basis of industry development, promotion, planning, and forecasting.

Although the greatest share of the growth of this fishery has taken place in Samoa, business people and fishermen in American Samoa have demonstrated great interest in buying, building, and operating alia fishing boats to enter this fishery. The rapid expansion of the small-scale longline fishery for albacore since 1991 has been quite impressive. In Samoa, the number of alia longliners exceeded 200 in 1998 (Mulipola, 1998). In American Samoa the fleet grew from less than five alia boats using longline gear in 1996 to 24 in 1997.

3.2.2. Expert fishermen

Expert fishermen were selected with the assistance of the Ministry of Agriculture and Fisheries in Samoa and the Department of Marine and Water Resources in American Samoa. Eleven alia longline fishermen were interviewed individually in Samoa and in American Samoa. The expertise of the fishermen was initially questioned because of the apparent lack of confidence in answering questions. It was determined that these fishermen for the most part had very few years fishing and in-depth resource knowledge was lacking. The number of years fishing in Samoa ranged from 1 to 16 years. The average number of years was 4.36. One fisherman stood out from the group in American Samoa in that he operated a 60-foot longliner and did not fish using the smaller alia. If this individual is removed, the average years in the fishery becomes 3.2. Seven of the fishermen had fished for less than 2.5 years. Fishermen tended to provide responses based on what they learned from others and not based on personal experience or belief.

Applying cultural consensus analysis of fishermen's responses to assess expert consensus was not appropriate for the Samoa fishery. It appears that the growth of this fishery is not based on significant knowledge of the albacore resource, but rather on the basis of a new economic opportunity. Problems in the agriculture sector and the lack of other employment opportunities in Samoa have led to increased emphasis on developing this fishery. It was determined that many of the fishermen in this fishery were farmers a short time ago and that many fishermen were recruited to fish for boat owners (who also lacked fishing experience) who had the capital to invest in fishing ventures.

The interviews and responses to albacore resource belief statements are presented without the benefit of statistical analysis afforded by cultural consensus analysis procedures (Table 3). The information is helpful in characterizing the fishery and the participants.

Table 3. Samoa albacore fishery resource propositions and responses

No.	Belief statement about the albacore resource	Responses		
18.	Albacore are in Samoan waters year round.	True 10	False 1	
21.	Albacore catch is seasonal.	True 8	False 3	
28.	Albacore abundance is greater outside of your current range.	True 8	False 2	Don't know 1
34.	Albacore catch remains the same from year to year.	True 9		Don't know 2
41.	Albacore size changes greatly from year to year.	True 1	False 8	Don't know 2
45.	Albacore spawn in Samoan waters.	True 2	False 2	Don't know 7
46.	Albacore caught in Samoa are mature.	True 6		Don't know 5
48.	Albacore is being overfished in Samoa.		False 10	Don't know 1
49.	Albacore is being overfished in the Pacific Ocean.		False 9	Don't know 2
50.	Albacore can be depleted by local fishing effort.	True 1	False 7	Don't know 3
51.	Albacore can be depleted by hook and line methods on the Pacific-wide population.	True 1	False 6	Don't know 4
52.	Albacore in the Pacific can be depleted by drift gill netting.	True 4		Don't know 7
53.	It is necessary to limit the number of boats fishing in American Samoa to prevent overfishing.	True 4	False 2	Don't know 5
54.	It is necessary to limit the number of boats fishing in Samoa and American Samoa to prevent overfishing.	True 4	False 7	
55.	It is necessary to limit the number of boats fishing in the South Pacific to prevent overfishing.	True 3	False 4	Don't know 4

Table 4 presents the summarized findings based on other questions asked during interviews that help to characterize this new fishery.

Table 4. Questions characterizing the Samoan albacore fishery

No.	Questions about the albacore fishery	Responses
1.	How do you fish?	Longline (11)
2.	When do you fish?	Day (11)
3.	How long are your trips?	15 to 18 hrs. (11)
4.	How did you learn to fish this way?	Other Samoan fishermen (7) Other fishermen (4)
5.	Did you know about albacore 10 years ago?	Yes (4), No (7)
6.	Is albacore fishing something new for Samoan fishermen?	Yes (7), No (4)
7.	How far from shore do you fish?	8 to 25 miles. (11)
8.	How much fish do you catch?	500 to 2,000 lbs, average 1,000 lbs per trip. (11)
9.	What size albacore do you catch?	20 to 70, average 35 lbs. (11)
10.	What is the smallest fish?	20 lbs. (11)
11.	What is the largest fish?	50 to 70, average 65 lbs. (11)
12.	Do you catch larger and small albacore in the same time in the same place?	Yes (10), No (1)
13.	Have you seen ripe eggs in albacore?	Yes (4), No (2), Don't know (5)
14.	Do you catch other species of fish?	Yes (11)
15.	Do you try to catch other species of fish?	Yes (1), No (10)
16.	Do you have special places where you can make good catches of albacore?	Yes (11)
17.	Are these areas associated with fast currents?	Yes (2), No (9)
18.	Are these areas associated with the ocean bottom?	Yes (7), No (4)
19.	Are these areas associated with seamounts?	Yes (3), No (8)
20	Are these areas associated with ocean temperature?	No (11)
21.	Are these areas associated with traditionally good fishing areas?	Yes (2), No (9)
22.	How much ice do you take on your trips?	None (8) 250 to 500 lbs. (1) 500 to 1000 lbs. (2)
23.	How many hours on average, after catching the fish do you deliver to the cannery or freezer?	>8 hours (11)
24.	What is the longest time after catching the first tuna until delivery to the cannery or freezer?	12–14 hours (11)
25.	Do you know what histamine poisoning or scombroid fish poisoning is?	Yes (1) No (10)
26.	Do you know how it is prevented?	Yes (1) No (10)

3.2.3. Management implications

The interviews offered an opportunity to characterize this fishery and determine some of the fishing practices. The management implications for small-scale pelagic fisheries development follow.

3.2.3.1. Years of fishing albacore

The interviews revealed a relatively short time frame of experience in the small-scale longline fishery for albacore in Samoa and American Samoa. Most fishermen are relatively new in the fishing industry and in-depth knowledge of the albacore resource was generally lacking.

3.2.3.2. Vessel and crew safety

The survey effort identified a lack of basic seamanship skills in the fleet of fishermen recently recruited by vessel owners. Only one of the fishermen interviewed had any navigational skills. The majority relied on triangulation techniques for positioning and needed to remain within sight of land. Few boats had reliable communications with shore. Many captains contracted by vessel owners reported that they were simply instructed to follow other boats and "do what they do" as the extent of their training. The lack of vessel safety is another great concern. With the rush to construct new alia, some builders neglected to properly foam the hulls and pay close attention to the quality of the welding. A number of the newer alia have sunk without a trace and about 20 lives have been lost.

3.2.3.3. Knowledge of histamine poisoning (scombroid fish poisoning)

Histamine poisoning (also known as *scombroid fish poisoning*) occurs when certain types of pelagic fish are mishandled and subjected to extensive time-temperature abuse. The combination of delayed chilling, poor temperature control, and inadequate sanitation on board fishing vessels is considered the most important cause of histamine accumulation. Interviews with the quality control personnel at the StarKist cannery revealed occasional problems with odors of decomposition and high histamine in albacore from the Samoan alia longline fleet. Each fish species has a different predisposition to forming histamine. Albacore is known to be relatively resistant to forming histamine when compared to mahimahi and the other tuna species. Finding histamine problems with albacore is unusual and indicates significant post-harvest mishandling.

Only one of the fishermen interviewed had any knowledge of histamine poisoning, what causes it, and how to prevent it. Fishermen in this fleet will need to be educated about this food safety hazard, quality standards, and effective methods for prevention.

3.2.3.4. Knowledge of basic on-board fish handling

It was estimated that only 5 to 6 boats out of a combined fleet of 160-170 boats used ice during their fishing trips. At the time of the interviews, this reflected a large information gap between the fishermen, vessel owners, and the canneries buying the albacore. The internal fish temperature of these fish was found to be 75-80° F when delivered to the shore freezers. The total delay from the time of capture to the beginning of freezing was estimated to be as much as 12 hours.

The fish handling typical of the Samoan albacore fishery may be marginally adequate for the canning market, but to access fresh export markets there needs to be significant improvements. Compliance with US FDA hazard analysis critical control point (HACCP) regulations will not be an easy task in Samoa without fundamental changes in how fish are handled at sea and onshore. Training in HACCP, sanitation, and proper temperature controls are the most pressing needs. Fishermen and fish processors/exporters both need to understand the nature of histamine accumulation and their respective responsibilities in preventing histamine-related public health problems.

The canneries in American Samoa and fish importers in the US are required to ensure that tuna and other pelagic fish species that are known to form histamine have been handled properly by fishermen. The FDA requires that histamine-forming fish be chilled to below 50° F within 6 hours of death and below 40° F within a total of 24 hours. In addition, the FDA requires that tuna muscle samples contain no more than 5 mg% histamine. In order to comply, importers must either test for histamine by lot sampling or provide detailed on-board fish handling records to verify proper (safe) handling conditions.

At the time of the interviews, the overwhelming majority of boats in this fleet did not use ice and were not meeting the FDA chilling targets for on-board handling. Both American Samoa and Samoa fleets depend on the cannery market in Pago Pago where FDA HACCP regulations apply. This situation remains a serious liability to the fishery. Compounding this problem, fish are frozen on-shore and often these freezers are incapable of rapid freezing. The excessive cumulative time and temperature abuse of albacore remains a serious concern.

It is important to support the Samoan and American Samoan efforts to build a sustainable domestic fishing industry because there are so few examples of successful pelagic fisheries accessible to Pacific Islanders. Fisheries managers and those in charge of economic development in the islands should support this fishery with training in vessel safety and safe fish handling to address these serious vulnerabilities. Fisheries scientists should carefully monitor albacore catch statistics to develop the scientific assessment of the albacore population in Samoa, at the same time they actively promote entry to this fishery.

3.2.4. Fishermen's expert insights

Samoan fishermen were introduced to vertical longlining but quickly converted to the horizontal longlining, which is the more efficient practice. Several fishermen were quick to point out that although they learned the techniques from trainers from outside of Samoa, that the fishing method only became highly effective for targeting albacore after the method of setting gear was modified by Samoan fishermen. This style was developed through practical experience after fishermen determined that the swimming depth of albacore in the fishing area was below 45 fathoms (Fa'asili and Time, 1997). By adjusting the number of hooks between floats, the Samoan style or local fine-tuning resulted in what are thought to be greatly improved catch rates.

3.2.5. Conclusion

The small-scale albacore alia longline fishery in Samoa is a relatively new endeavor. Entrants into this fishery have a limited period of fishing experience on which to base resource beliefs. The finding that local knowledge about the albacore resource was underdeveloped is an important finding in itself. Managers and policymakers need to recognize that the rush to enter this fishery and promote its development is not based upon long term, in-depth knowledge of albacore resource abundance, or distribution within the range of the small-boat fleet. Due to the limited time frame of experience in this fleet, there is little historic basis on which to encourage or caution investors from entering this fishery.

Management issues impacting American Samoa albacore fishermen relate to issues of allocation, control of entry into the fishery, restrictions on the size of vessels, and the issue of encroachment of Samoan fishermen into the EEZ of American Samoa. In American Samoa, when the fleet reached 24 alia in 1997, there were concerns about further expansion of the fleet, restrictions on the size of vessels allowed to fish for albacore, and a general desire to control entry into the fishery. There are basic differences between the two jurisdictions in regard to the fishery. By contrast, in Samoa the government is actively promoting entry into the fishery and the fleet has grown rapidly to exceed 200 vessels.

3.3. Results: Blue marlin resource knowledge held by Guam commercial troll fishermen

3.3.1. Fishery management context

The troll fishery for blue marlin in Guam is very important to the local commercial and recreational trollers. Guam also has an important fresh tuna transshipment industry that services foreign flag longline vessels operating out of the Port of Guam and fishing south of Guam. The local knowledge held by Guam fishermen about the marlin resource is potentially important to fisheries managers when considering possible interaction between the Guam troll fleet and the distant water, foreign flag tuna fleet in terms of marlin and other pelagic fish catch.

3.3.2. Expert fishermen

Fourteen expert fishermen with experience trolling commercially for marlin and other large pelagic fish in Guam waters were selected for the interviews. These individuals qualified either as full-time charterboat captains, commercial fishermen, or part-time commercial fishermen. Expert troll fishermen were identified with the assistance of the Guam Fishermen's Cooperative and local seafood wholesalers. The group of fishermen selected ranged from 6 up to 47 years in the fishery, had an average of 22.3 years of experience, and represented a total of 312 years of fishing for marlin in Guam waters.

3.3.3. Cultural consensus analysis

3.3.3.1. Were these individuals experts (competency scores)?
Yes. The group of fishermen had competency scores that establish that they are knowledgeable experts about the Guam marlin fishery.

Matches method: Using the matches method to measure agreement among respondents, the ratio of the first to the second eigenvalue was 3.27. This indicated that the group shared a body of knowledge (prerequisite ratio >3.00). The average competency score for the group was 0.499 (s.d. 0.163, range 0.33 to 0.77) (prerequisite value >0.50).

Covariance method: Using the covariance method, the eigenvalue ratio was only 2.85 and the mean competency score was 0.447 (s.d. 0.199). This indicated that the matches method produced a better fit. The results of the matches method were used for further analysis.

3.3.3.2. Is there a consensus on the set of resource propositions (answer key)?
Yes. Consensus analysis supports the conclusion that the respondents share a single cultural knowledge base. This is a finding of consensus. The resource propositions and the cultural consensus (answer key) are presented in Table 5.

Table 5. Guam marlin fishery resource propositions and consensus

No.	Belief statement about the marlin resource	Consensus	
1.	Marlin can be caught trolling in areas where birds are feeding.	**TRUE❶**** 12	False 2
2.	Marlin can be caught trolling around FADs.	**TRUE**** 14	False 0
3.	Marlin can be caught trolling in debris lines.	**TRUE**** 9	False 5
4.	Marlin can be caught trolling with live bait.	**TRUE**** 11	False 3
5.	Marlin are in Guam waters year-round.	**TRUE**** 12	False 2
6.	Marlin abundance in Guam waters is high during winter (Nov-Dec).	True 1	**FALSE**** 13
7.	Marlin abundance in Guam waters is high during spring (Jan-Apr).	True 1	**FALSE**** 13
8.	Marlin abundance in Guam waters is high during summer (May-Aug).	**TRUE**** 13	False 1
9.	Marlin abundance in Guam waters is high during fall (Sep-Oct).	**TRUE** 7 (0.554)❷	False 7
10.	Marlin movements are dependent on specific conditions related to current.	**TRUE**** 13	False 1
11.	Marlin movements are dependent on specific conditions related to ocean temperature.	**TRUE**** 13	False 1
12.	Marlin movements are dependent on specific conditions related to bottom topography.	**TRUE**** 10	False 4
13	Marlin movements are dependent on specific conditions related to the moon phase.	**TRUE**** 9	False 3
14.	Marlin can see color.	**TRUE** 5 (0.759)	False 5
15.	A good marlin year in Guam is related to higher ocean temperature.	True 6	**FALSE** 7 (0.843)
16.	A good marlin year in Guam is related to greater rainfall/runoff.	True 3	**FALSE**** 10
17.	A good marlin year in Guam is related to strong trade winds.	True 5	**FALSE**** 9
18.	A good marlin year in Guam is related to high abundance of feed (baitfish).	**TRUE**** 12	False 2
19.	A good marlin year in Guam is related to El Nino years.	**TRUE** 6 (0.737)	False 7
20.	A good marlin year in Guam is related to a good year for marlin throughout the western Pacific.	**TRUE*** 8	False 6
21.	Marlins in Guam are wide-ranging or migratory.	**TRUE**** 13	False 1
22.	Marlin in Guam are resident, remain within Guam waters.	True 5	**FALSE**** 9
23.	Marlins in Guam are a mixture of wide-ranging and resident fish.	True 7	**FALSE**** 7
24.	Marlin use Guam waters as a spawning area.	**TRUE**** 9	False 5
25.	Marlin use Guam waters as a nursery for the young fish.	**TRUE**** 9	False 5

26.	Marlin use Guam waters as one more feeding stop on route for the adult fish.	**TRUE**** 14	False 0
27.	Marlins found in Guam waters are spawned here and develop into juveniles.	True 6	**FALSE**** 8
28.	Marlins found in Guam waters arrive as juveniles and grow into young adults.	True 8	**FALSE** 6 (0.840)
29.	Marlins found in Guam waters are young adults that mature and spawn here.	True 6	**FALSE** 8 (0.90)
30.	Marlins found in Guam waters are large mature adults and take up residence late in life.	True 6	**FALSE**** 8
31.	Blue Marlin are currently vulnerable to overfishing in Guam.	**TRUE**** 8	False 6
32.	Yellowfin are currently vulnerable to overfishing in Guam.	True 6	**FALSE** 8 (0.90)
33.	Skipjack are currently vulnerable to overfishing in Guam.	True 5	**FALSE**** 8
34.	Mahimahi are currently vulnerable to overfishing in Guam.	True 2	**FALSE**** 12
35.	Wahoo are currently vulnerable to overfishing in Guam.	True 4	**FALSE**** 9
36.	Marlin are being overfished in the western Pacific region with the existing fleets and fishing levels (including longline and purse seine)	**TRUE**** 12	False 2
37.	Longline fishing in the region is currently heavy enough to cause marlin abundance in Guam to decline to a problem level (e.g., cause economic problems for local charterfishing fleet).	**TRUE**** 11	False 3
38.	Purse seine fishing in the region is currently heavy enough to cause marlin abundance in Guam to decline to a problem level (e.g., cause economic problems for local charterfishing fleet).	**TRUE**** 9	False 5

❶ = the bolded answer is the consensus
❷ = if probability is less than 0.95, it is reported in parentheses
* = probability is greater than 0.95 ** = probability is greater than 0.99

Cultural consensus analysis derived the consensus view of the blue marlin resource shared among the select group of troll fishermen in Guam. While there was consensus, the group was divided on several issues. The first question was about whether blue marlin are abundant in Guam during September and October, the fall season (question 9). The group also disagreed on whether blue marlin can see color (question 14), a commonly asked and debated question that relates to the selection and effectiveness of trolling lures. The group was also divided on whether warmer water temperature and El Nino years were associated with good blue marlin years (questions 15 and 19). Although the group agreed that marlins use Guam waters for all life stages, they did not believe that fish spawned in Guam necessarily completed their entire lives near Guam (questions 28 and 29). Instead they believed that blue marlin arrive in (and depart) Guam at various stages of life depending on wide ranging movements. The group was also divided on whether yellowfin tuna were susceptible to overfishing in Guam (question 32).

3.3.3.3. How much agreement among is there between experts (similarity matrix)?

An agreement matrix generated by the consensus analysis indicating the proportion of matches (corrected for guessing) between each pair of respondents was submitted to non-metric MDS to graphically represent the similarity of respondents in terms of their response patterns. Figure 2 shows the first two dimensions of the MDS solution (stress = 0.194 achieved after 35 iterations).

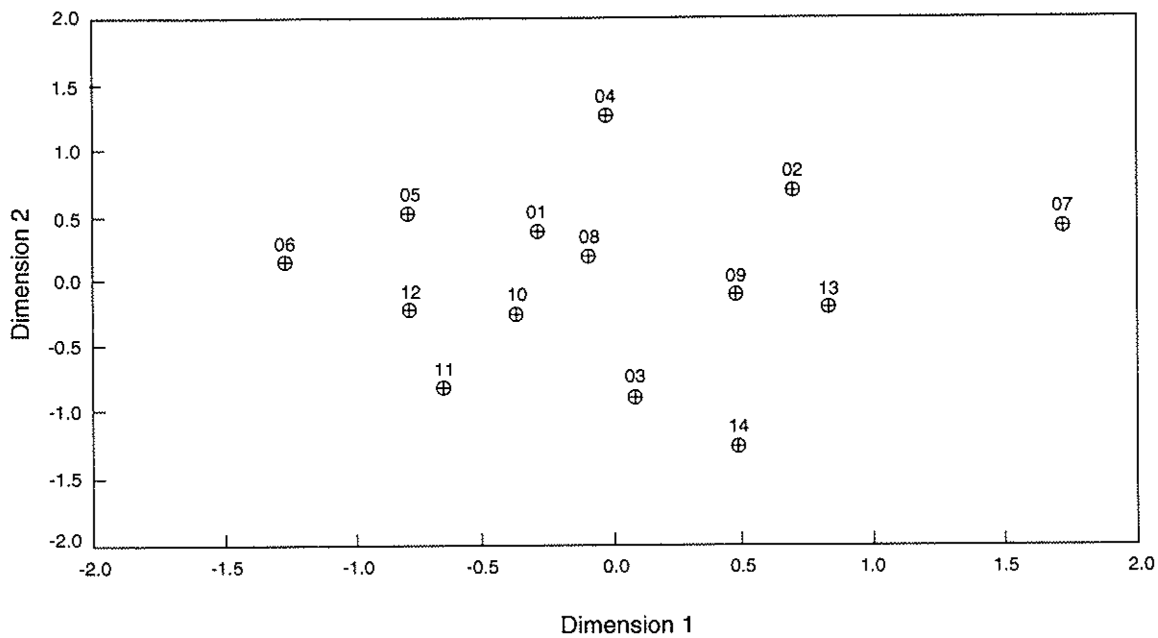

Figure 2. Guam Marlin Knowledge Similarity Matrix

The numbers plotted represent individual respondents. The figure reveals that the fishermen interviewed are dispersed with no conspicuous clustering. This suggests that the Guam troll fishermen share a single perspective on the body of blue marlin resource propositions and do not differ markedly among themselves.

3.3.4. Management implications

Guam troll fishermen believed that blue marlin caught in Guam waters are not resident, and that they belong to a wide-ranging central population. They also believed that blue marlin use Guam waters during various life stages as a spawning area, nursery for young, and as feeding grounds for mature adults. This indicates a need for research and management efforts that address ocean-scale, as well as localized population dynamics.

The group believed that blue marlin are currently vulnerable to overfishing in Guam waters. While the group recognized the relationship between the locally available blue marlin and the larger central population, they tended to interpret evidence derived from local fishing experience as being an indication of population-wide trends.

Guam's troll fishermen also believed that blue marlin are currently being overfished in western Pacific region at existing fishing levels. This is primarily based upon local trolling catch rates of blue marlin and the heightened awareness of longlining and purse seining activity in the region and the landing of blue marlins.

3.3.5. Fishermen's expert insights

During the interviews, Guam marlin fishermen expressed concerns about the yellowfin tuna resource in Guam waters. They reported a sharp decline in the troll catch rate of yellowfin since 1985. They also described a steady decline in the size of yellowfin since the 1970's. The yellowfin drought was a recurring theme expressed by this group of fishermen.

Interviews with fisheries scientists in Guam revealed no compelling evidence of any decline in the yellowfin population in the western Pacific. As in the Hawaii yellowfin tuna survey, fishermen and scientists differed in their source of evidence leading them to draw different conclusions about the yellowfin stock near Guam. Scientists focused on stock-wide resource assessments based largely on the analysis of catch data from large-scale international tuna fleets. Local Guam troll fishermen, however, have a more narrow view of their fishery. From the overwhelming evidence based on first-hand fishing experience, they conclude that the yellowfin tuna population in Guam waters is in serious decline in numbers and size.

Fishermen offer some possible explanations. First, they are suspicious of the negative impacts of purse seining in the region. To the fishermen, there is no coincidence that trolling for yellowfin declined with the expansion of purse seining in the western Pacific after 1980. Guam is home port for a small fleet of purse seiners that are an easy target of suspicion for small boat operators.

There are a number of possible reasons for the perceived decline in yellowfin abundance. Guam may be a fringe area for the greater yellowfin population. Localized population effects may not be a reflection of the central fishery. This may explain why western Pacific yellowfin catch data does not indicate any decline over the same period that local yellowfin catch and fish size in Guam has declined according to local fishermen.

There is also the possibility that fishermen have selective memories and have a set benchmark in 1978, the record year for yellowfin catch in Guam. Everything since that peak year looks like a serious decline. Japanese fishery data indicates that in 1978, the longline fishery in the western Pacific also had the best catch rate for yellowfin in 30 years. This indicates that 1978 was an exceptional year for yellowfin in the region and not just the local Guam fishery. With conditions of high fish abundance, the frontiers of yellowfin tuna range may expand and be detected as a year of high abundance in Guam waters. Conversely, a moderate decrease in the stock may reduce the range of yellowfin concentrations and produce exaggerated effects detected in the fringe areas such as in Guam.

Other possible factors include the ocean temperature changes around Guam. As solar heating increases and winds slacken during the late spring and summer, surface waters off Guam warm and stratify. The thermocline develops at shallow depths, making the mixed layer (where the yellowfin reside) more shallow. Changes in the usual seasonal weather pattern could affect yellowfin catchability to surface trollers.

Another possibility may be recent changes in fishing effort by the trolling fleet in Guam. With the growth of tourism, there has been an increased emphasis on charter fishing operations that might be more focused on the turnover of passengers than on catching fish. Some fishermen report that the non-charter boats have a much greater yellowfin catch rate (7X) than charter boats.

3.3.5. Conclusion

The expert group of troll fishermen shared a consensus view of the blue marlin resource and concerns about the yellowfin tuna abundance in Guam waters. The group was divided on several issues of interest. The group did not have a clear consensus on the relationship between warmer water temperatures and El Nino years with good years for the blue marlin fishery. With the heightened awareness of the El Nino events and their impacts on water circulation patterns, water temperature and fisheries production, it would be of interest to fishermen and fisheries scientists if these questions could be further investigated.

During the interview process, Guam fishermen offered observations and concerns about the yellowfin tuna resource within the range of their vessels. This additional expert input is of interest in that it points to the need for sharing yellowfin catch data from the western Pacific with Guam fishermen to emphasize the relationship between the greater yellowfin tuna population and the shifts in tuna abundance at the local level. As in Hawaii's handline fishery, fishermen detect local impacts which may not be readily apparent in the larger international data collection systems. Local fishery impacts are the principal experience of trollers and handliners that have limited fishing range. Guam trollers have understandable concerns about the impacts of larger-scale fishing activity in the western Pacific region by longliners and purse seiners on local fish availability in Guam. Research and the sharing of information on regional fishing activity and fish populations may help fishermen and scientists to better understand the relationships between the greater fish populations and the shifts in fish abundance detected in localized fisheries. This also supports the need for accurate catch reporting by local commercial and recreational troll fishermen in order to evaluate the potential for local impacts from fishing activity beyond the range of the Guam based trollers.

3.4. Results: Bigeye tuna resource knowledge held by Hawaii longline fishermen

3.4.1. Fishery management context

The interviews with Hawaii yellowfin handline fishermen and pelagic fisheries scientists revealed that there is a general need for more in-depth knowledge concerning the bigeye tuna resource. Local knowledge of bigeye tuna was explored further by focusing attention on a group of long-term, Hawaii based, bigeye tuna longline fishermen for interviews. Fishery managers stand to benefit from insights on the bigeye tuna resource from fishermen in Hawaii. This is especially important in light of the current inadequacy of scientific knowledge of bigeye in the Pacific and management concerns about the status of the bigeye population and international fishery.

3.4.2. Expert fishermen

Longline fishermen with experience targeting bigeye tuna were identified with the assistance of key informants in the industry. A total of 14 fishermen with a minimum of 15 years in the

3.4.2. *Expert fishermen*

Longline fishermen with experience targeting bigeye tuna were identified with the assistance of key informants in the industry. A total of 14 fishermen with a minimum of 15 years in the longline fishery for bigeye tuna in Hawaii were selected as an expert group for interviews. The number of years of experience ranged from 15 to 40 years. Some of the fishermen (retired) had started longline fishing as far back as 1938. The average number of years fishing among this group was 24.7 years and the cumulative number of years represented was 346.

3.4.3. *Cultural consensus analysis*

3.4.3.1. *Were these individuals experts (competency scores)?*

Yes. Consensus analysis supports the conclusion that the 14 fishermen interviewed share a clear consensus in their responses to the 27 belief statements about bigeye tuna in Hawaii.

Matches method: Using the matches method to measure agreement among respondents, the ratio of the first to the second eigenvalue was 5.94. This indicated that the group shared a body of knowledge (prerequisite ratio >3.00). The average competency score for the group was 0.661 (s.d. 0.170, range 0.41 to 0.92) (prerequisite value >0.50).

Covariance method: Using the covariance method, the eigenvalue ratio was 5.66 and the mean competency score was 0.655 (s.d. 0.182, range 0.35 to 0.90). This indicated that the matches method produced a slightly better fit. The results of the matches method were used for further analysis.

3.4.3.2. *Is there a consensus on the set of resource propositions (answer key)?*

Yes. Answer keys generated by the matches method and the covariance method were identical. The answer key generated by this group of expert bigeye longline fishermen is presented in Table 6.

Table 6. Hawaii bigeye fishery resource propositions and consensus

No.	Belief statement about the bigeye tuna resource	Consensus	
1.	Bigeye tuna caught in Hawaii are part of a wide-ranging, migratory population.	TRUE●** 13	False 1
2.	Most of the bigeye tuna caught in Hawaii do not take up temporary residence at off shore seamounts at some time during their lives.	TRUE** 11	False 3
3.	Most of the bigeye tuna caught in Hawaii are spawned in Hawaii waters (within fishing range).	True 3	FALSE** 11
4.	Most of the bigeye tuna caught in Hawaii are spawned at the offshore seamounts.	True 0	FALSE** 14
5.	Summer (Northern Hemisphere) is not the spawning season (where ever it occurs) for bigeye tuna caught in Hawaii.	True 1	FALSE** 13
6.	Bigeye tuna are caught in Hawaii mostly in the winter because they move to other areas in the summer.	TRUE** 13	False 1
7.	It is possible to make large catches of large bigeye tuna in inter-island channels.	TRUE** 13	False 1
8.	There are seamounts (specific locations with subsurface features, which tend to aggregate fish) where large bigeye tuna are concentrated.	True 6	False* 8

9.	Bigeye tuna do not come close to shore (like yellowfin).	True 4	**FALSE**** 10
10.	Bigeye tuna come close to shore in Hawaii in the fall when they arrive and later in the spring when they leave.	**TRUE**** 12	False 2
11.	Bigeye tuna tend to travel in schools made up of single size/year classes.	True 4	**FALSE**** 10
12.	The abundance of bigeye tuna in Hawaii does not depend on how much fishing occurs in and around the 200-mile zone.	**TRUE**** 11	False 3
13.	The abundance of bigeye tuna in Hawaii does not depend on how much fishing is done before the fish migrate near Hawaii.	**TRUE**** 9	False 5
14.	The abundance of bigeye tuna in Hawaii depends on the availability of food (prey) in Hawaii waters.	**TRUE**** 13	False 1
15.	The bigeye tuna abundance in Hawaii depends on variations in thermocline depth (cold water layer).	**TRUE**** 13	False 1
16.	That variation in bigeye tuna abundance in Hawaii depends on variation in fish abundance ocean-wide (outside of Hawaii).	**TRUE**** 13	False 1
17.	Bigeye tuna catch is strongly affected by the full moon.	True 4	**FALSE**** 10
18.	Bigeye tuna do not have extreme variations in abundance from year to year (good years and bad years).	True 4	**FALSE**** 10
19	Bigeye tuna caught in summer has soft textured muscle because of spawning.	**TRUE**** 14	False 0
20.	Bigeye tuna caught in summer has soft textured muscle because of warmer water temperature.	**TRUE**** 12	False 2
21.	The bigeye tuna resource in Hawaii is being overfished (present yields are not sustainable).	True 0	**FALSE**** 14
22.	The bigeye tuna resource in the central and western Pacific is being overfished (present yields are not sustainable).	True 2	**FALSE**** 12
23.	The bigeye tuna resource in the central and western Pacific is being reduced due to bigeye catches in purse seine vessels setting on FADs in the eastern Pacific.	**TRUE**** 11	False 2
24.	The size of bigeye caught in Hawaii is staying the same.	**TRUE*** 7	False 7
25.	The bigeye tuna resource in Hawaii is not as abundant as 10 years ago.	True 5	**FALSE**** 9
26.	Heavy fishing by existing Hawaii boats alone could not deplete bigeye tuna abundance in Hawaii.	**True**** 13	False 1
27.	Heavy fishing of small bigeye tuna at seamounts, weather buoys, and FADs will cause a decline in the future abundance of large bigeye tuna in Hawaii.	**TRUE**** 8	False 6

❶ = the bolded answer is the consensus
* = probability is greater than 0.95 ** = probability is greater than 0.99.

3.4.3.3. How much agreement among is there between experts (similarity matrix)?

An agreement matrix generated by the consensus analysis indicating the proportion of matches (corrected for guessing) between each pair of respondents, was submitted to non-metric MDS to represent graphically the similarity of respondents in terms of their response patterns. Figure 3 shows the first two dimensions of the MDS solution (stress = 0.151 achieved in 21 iterations).

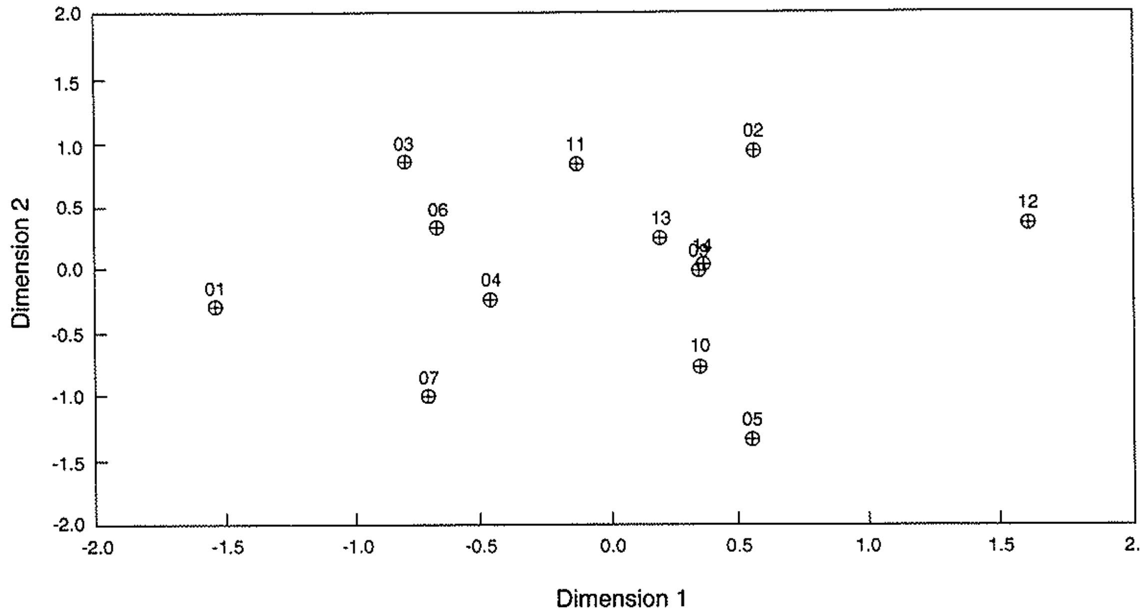

Figure 3. Hawaii Bigeye Knowlege Similarity Matrix

The numbers plotted represent individual respondents. The figure reveals that the longline fishermen interviewed are dispersed with no conspicuous clustering. This suggests that the Hawaii longline fishermen share a single perspective on the body of bigeye tuna resource propositions and do not differ markedly among themselves.

3.4.4. Management implications

The group of bigeye longline fishermen in Hawaii believe that the bigeye tuna is wide ranging, does not spawn in Hawaii waters, has a seasonal pattern of abundance, and can be caught in close to shore and in the inter-island channels during certain times of the year. This group of fishermen has a long history of fishing for bigeye in Hawaii on which they base these beliefs.

Management efforts to reduce the likelihood of fleet/gear conflicts and issues of stock allocation include area closures and gear restrictions. Conflict between longliners and small boat fleets of trollers and handliners are serious management issues. By applying the expert knowledge of bigeye tuna fishermen, managers might consider modifying area closures to accommodate seasonal shifts in bigeye and yellowfin tuna distribution.

During the summer half of the year when yellowfin come in closer to shore and the bulk of the small boat commercial and recreational fishing activity occurs in Hawaii, longliners could be excluded from the nearshore by area closures. However, later in the year during the winter season when bigeye tuna move closer to shore and yellowfin have moved away from the islands, the area closures could be relaxed. The weather and sea conditions restrict the small boat fishing activity during this time of year and the potential for gear conflict is naturally reduced. This modified management approach would apply scientific and local fisheries knowledge to controlling gear conflicts while reducing the negative economic burden on longline fishermen.

This would allow bigeye fishermen access to their traditional fishing grounds nearer to shore and even within inter-island channels during the most important fishing season of the year when prices for bigeye tuna are at a premium.

3.4.5. Fishermen's expert insights

Fishermen were divided over questions relating to the trends in bigeye tuna abundance and average size. One explanation for a perceived decline in bigeye size was offered. Some fishermen reported that the old style "basket" gear can be set deeper which increases the catch of larger-sized bigeye tuna. Larger bigeye caught in colder deeper water layers have better quality and are of higher value. The basket gear takes much longer to haul, so the fishermen must make a decision that balances the positive aspects of the older type gear with the decreased efficiencies. Because the majority of the Hawaii longline fleet has switched to monofilament longline gear, the sets are not as deep and the average size of bigeye being caught appears to have declined. This may be partially a reflection of the type of gear and depth of set rather than significant changes in the average size of bigeye in the population.

Fishermen believe that bigeye tuna run in schools of mixed size classes. Some fishermen explained that they believe that this has not always been the case. Some report that fish used to be larger and run in schools of more uniform size classes. Some fishermen consider the mixed size classes in schools to be a bad sign for the population. Others explained that this might be another result of changes in longline gear, depth of gear placement, and fishing efficiencies. Fishermen believe that in mixed schools, the 40 to 50 lb fish are more aggressive, seem to be stronger than the older larger fish, and tend to lead the school. The larger sized fish 80 to over 100 lb seem to follow the smaller fish.

Some fishermen noted that the catch of large bigeye near the island of Hawaii was much better prior to beginning of the eruption of the Kilauea volcano, which has flowed continuously since 1983.

Bigeye fishermen share a concern about the harvest of small bigeye tuna at the offshore seamounts and also the take of small bigeye by purse seiners in the eastern Pacific Ocean. Fisheries scientists share both of these concerns and research is underway to monitor these fisheries and to assess the potential impacts.

3.4.6. Conclusion

Hawaii bigeye tuna longline fishermen share a strong consensus view on the bigeye resource. The relative lack of scientific information on bigeye tuna has prompted increased research efforts on bigeye in recent years. The handline fishermen on the island of Hawaii who target yellowfin tuna primarily, did not have a strong consensus about the bigeye resource due to a relative lack of experience. The questions asked of the longline fishermen who have extensive first-hand experience targeting bigeye tuna are important in developing a fishermen's view of the bigeye tuna movements, aggregations, population status, and impacts of fishing activity. The consensus view of the bigeye resource held by this expert group is potentially helpful to fisheries scientists in developing research projects, confirming hypotheses, and stimulating further investigation.

Effective management of the bigeye tuna resource depends on a greater understanding of the range of basic resource questions asked of the fishermen.

4. DISCUSSION

Fishery managers are charged with ensuring the sustainable future of the fish populations under their management while allowing optimum utilization of the resource by increasingly divergent user groups. Cultural consensus analysis has been proposed as a quantitative method for deriving the consensus view of any constituent group by analyzing responses to a list of resource propositions.

Both the number of participating groups and the positions on management issues that they represent are growing. Public debate and conflict over resource issues becomes more complex as additional participants become recognized as stakeholders. During public policy debate, participants tend to gravitate to extreme positions on issues in order to maximize their bargaining room in negotiations and compromise.

Conflict between user groups, scientists, and managers can be traced to basic differences in the beliefs held by these groups about the biological, social, cultural, economic, and political factors that comprise the system under management. Constituent groups are often polarized on key resource management issues simply because they differ in perspective or beliefs about the resource being managed. Consensus analysis may help managers to decipher the basis for the polarization. This method can help to eliminate some of the noise in the management system that is encouraged when divergent stakeholder groups are pitted against each other in a public policy process in which consensus is derived through debate, negotiation and politics.

By first understanding the information, knowledge, and experiential foundation of the set of beliefs shared by stakeholder groups, it is possible to systematically dissect the divergent positions taken on management issues into differences.

- *How should resources be used?* The goals and objectives within the context of the management system including economic utilization, employment generation, recreation, publicity, funding, etc.

- *What information or knowledge is relevant?* The data or experience base that is used by each group that shapes their consensus view of the resource management system and helps to formulate positions on management policy.

- *What the information means?* The interpretation of the data or experience base.

- *How we should respond and what policies should be applied?* What are the best management options to respond to the resource management problems.

Cultural consensus analysis can be a potentially powerful tool for fishery managers in problem scoping and assessment by defining the basis (scientific evidence, experience, etc.) of any positions taken by groups or subgroups of individuals participating in the management process.

The method is capable of determining if a group shares (or lacks) a consensus view, the cultural competence of individuals within the group, and analysis of specific resource questions or propositions that groups agree on and those on which they disagree. By using consensus analysis, managers may be able to sort through the rhetoric and posturing inherent in the current public policy management system and begin to illuminate specific issues that require further discussion, research, analysis, information summary, distribution, and community outreach.

Conflict can be reduced and management decisions can be reached when stakeholders are encouraged to share relevant data and its interpretation. With a shared consensus view of resources, what remains in the debate over which management options to select will be primarily a matter of different objectives and motivations of the various constituent groups. It is then up to the fisheries managers to overlay agency guidelines in assigning priority needs and resource use leading to the selection of the best management policy approaches.

Cultural consensus analysis was applied in four different fisheries in order to determine the consensus view of the resource held by select groups of experts. With each successive application, the team refined the methodology leading to the demonstration of a potentially valuable and practical management tool. Through this project effort, the application of cultural consensus analysis evolved from previous research focused on developing the statistical analysis, to a method that is focused on what people believe and how that understanding can be of practical value in the management context. Cultural consensus analysis has the potential to be useful in decision making by helping resource managers to analyze the consensus of any selected expert advice and opinion on any given issue.

The process of eliciting input from fishermen is also valuable in that as a constituent group, they are commonly asked only to react to management decisions and are not solicited for their practical knowledge as resource users. Engaging fishermen in the process of fisheries management is important for the simple reason that fishermen are the managed group. Fisheries scientists ultimately depend on input from fishermen in the form of catch data. Fishermen may be more likely to lend support to pertinent research efforts and to comply with fisheries management decisions if they take an active role in the management process by expressing their views on resource issues and development of research and management agenda. The fisheries management process stands to be enhanced by efforts that respect the beliefs and knowledge held by constituent groups and applies quantitative means of evaluating those beliefs.

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