A Network Analysis of Fisher's Social Capital and the Effects of Ethnic Diversity in Hawaii's Longline Fishery

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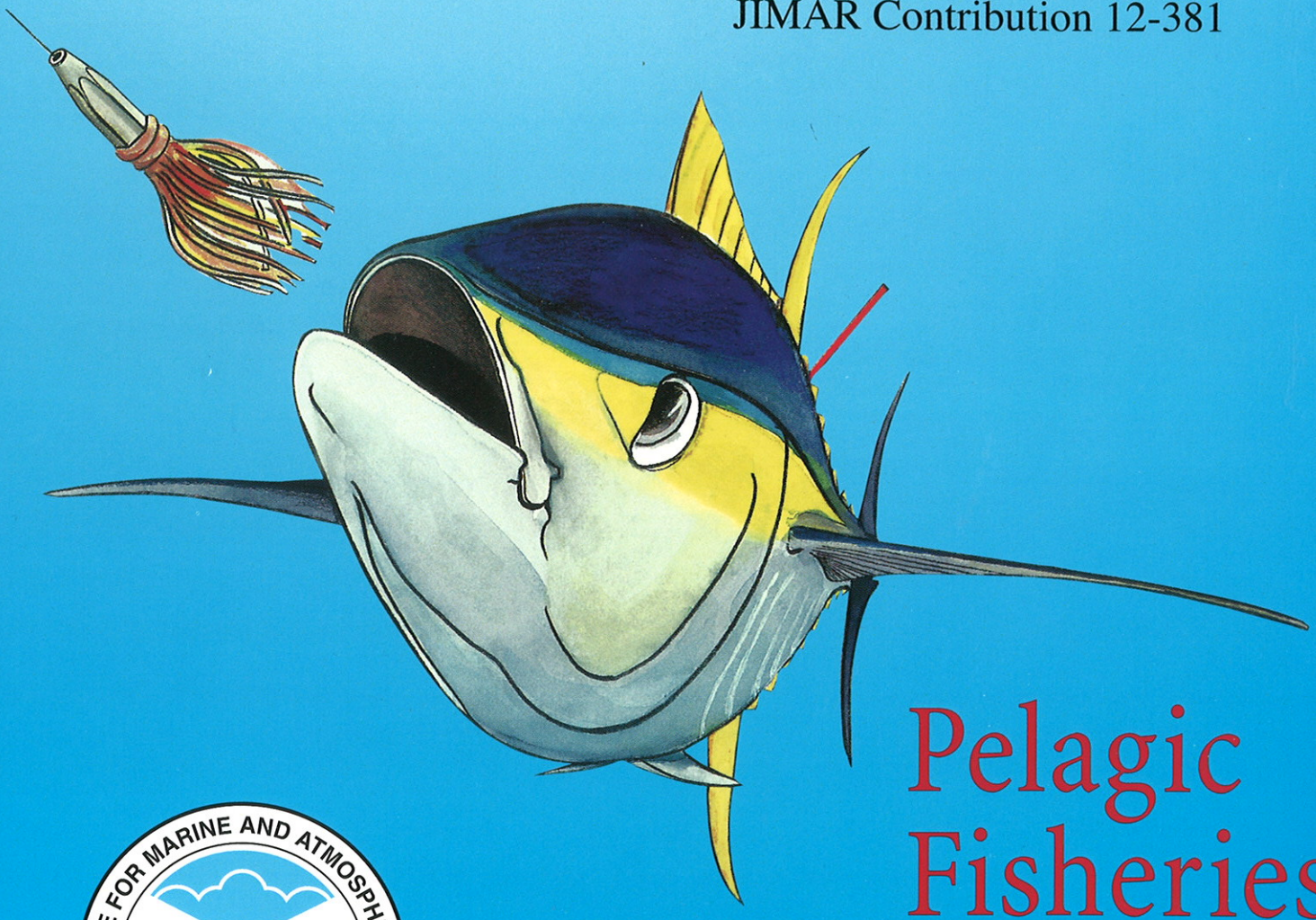

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Pelagic Fisheries Research Program

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1. BACKGROUND

Pelagic marine fisheries, like other natural resource systems, are dynamic and complex, comprised of multiple components often operating at various spatial and temporal scales (see Berkes et al. 2003). Due to this complexity and the dynamic nature of pelagic marine fisheries, individual fishers operate in a heterogeneous environment and are faced with a high level of uncertainty on a daily basis. To cope with this uncertainty, fishers not only learn from their past experiences, but may also rely heavily on sharing information within their social networks. Social networks are patterns of vertical and horizontal relationships, or "ties", among actors (Moore and Westley 2011), which can be comprised of various types of social relationships from casual to close bonds. Fishers' social networks, in this context, can consist of other fishers as well as supply store owners, industry leaders, scientists, management officials, or any other individual that fishers may share information with in order to mediate against the uncertainty associated with fishing. By forming relationships with others and sharing information within their social network, fishers are reacting to the problem of uncertainty by learning from each other, and from these social networks fishers can accrue *social capital*[1]—a contextual asset that can provide advantages to individuals or groups (Coleman 1988, Lin 1999).

There are three different types of social capital that have been identified as important in the context of marine fisheries: bonding, bridging, and linking. Bonding social capital involves strong social linkages within groups of like-minded individuals often characterized by dense, localized networks (Grafton 2005). Strong ties inherent in bonding social capital can be particularly beneficial in the context of fisheries due to the common-pool nature of the resource (Barnes-Mauthe et al. forthcoming). Fisheries resources can be added or depleted by the level of harvesting; harvesting is competitive because a fish that is taken by one vessel prevents it from being caught by another; and the ability to exclude others from harvesting is limited due to the mobility of the species (Grafton 2005). Therefore, trust and cooperation, which previous research suggests can be derived from social capital (e.g., Granovetter 1985, Coleman 1990, Pretty and Ward 2001, Hahn et al. 2006), is vital among fishers in encouraging individual fishers to observe standards, rules, and sustainable fishing practices, thus decreasing externalities for individual fishers (Grafton 2005).

Bridging social capital characterizes weaker linkages across somewhat similar, but different groups or social networks (Grafton 2005). Though bridging social capital ties tend to be weaker than those that make up bonding social capital, these ties have the advantage of linking heterogeneous groups or networks of people into a larger network. Sociological and organizational studies have shown that bridging ties bring with them an inherent diversity of ideas and perspectives that improve the capacity for the development of innovative solutions to complex problems, and can thus enhance adaptive capacity (Bodin and Crona 2009). For example, the existence of bridging social capital ties across heterogeneous groups can allow access to external resources and diverse knowledge, which can be essential for resource governance (Crona and Bodin 2006, Hahn et al. 2006, Newman and Dale 2007, Bodin and Crona 2009, Ramirez-Sanchez and Pinkerton 2009, Sandström and Rova 2010). Moreover, key actors forming bridging ties among smaller groups, or subgroups, may be capable of connecting and mobilizing these subgroups toward a common goal (Bodin and Crona 2009, Ramirez-Sanchez

[1] Though the term social capital has been criticized for its lack of clarity and consistency in the literature (Portes 2000, Durlaf 2002), it has been widely established that social relationships comprise an important component of social capital (see Coleman 1988, Burt 2000, Portes 2000, Putnam 2001, Lin 2002).

2011). It has also been shown that bridging ties can foster trust amongst previously unconnected groups or heterogeneous actors, which can further facilitate collaborative processes (Woolcock 2001, Bodin and Crona 2009).

Linking social capital, also referred to as cross-scale linkages, comprise ties across incongruent groups or networks at different hierarchical levels, such as connections between resource users and resource management officials (Grafton 2005). Links to outside governing agencies in the form of linking social capital can provide increased access to scientific knowledge (Grafton 2005) and information on technological innovations. Linking social capital can also help to ensure stakeholder interests are represented in the management and policy arena, and can facilitate stakeholder understanding and cooperation in regards to management initiatives (Barnes-Mauthe et al. forthcoming).

In this report, from a network perspective we characterize information sharing among Hawaii longline fishers and systematically examine the effects of ethnic diversity on bonding, bridging, and linking social capital, referred to here as *social network capital*. Hawaii's longline fishery (HLF) is a limited-entry multimillion dollar fishery, targeting predominantly bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and swordfish (*Xiphias gladius*), and is the dominant commercial fishery sector in the Hawaiian Islands (Allen et al. forthcoming). The fishery comprises approximately 120 active vessels, nearly all home ported in Honolulu at one of three piers, and is capped at 164 vessels (Allen et al. forthcoming). The HLF presents an ideal opportunity for this research because ownership of vessels is divided along ethnic lines; with roughly one-quarter owned and operated by Korean-American fishers (K-A), while the remaining vessels are split between Vietnamese-American (V-A) and Euro-American fishers (E-A) (Allen et al. forthcoming).

Previous ethnographic research on the HLF has shown that formal and informal social networks exist among longline owners and captains, but that most interaction occurs among individuals of the same ethnicity (see Allen et al. forthcoming). Moreover, differences among ethnic groups were found to exist in regards to operational practices and attitudes toward regulation (Allen et al. forthcoming). Therefore, understanding how ethnic diversity among resource users in the HLF, which is characterized by competitive interaction among individual fishers, may affect bonding, bridging, and linking social capital could provide important management implications and help to inform fishery policy[2].

2. OBJECTIVES

The purpose of this research is to examine information sharing and social networks among HLF fishers and to explore how ethnic diversity among fishers may be affecting the level and distribution of social network capital.

Specific objectives are outlined as follows.

1. Design and employ a detailed structured survey to collect sociodemographic, information sharing, and social network information on HLF fishers.
2. Examine sociodemographic and information sharing characteristics of HLF fishers.
3. Employ social network analysis (SNA) to analyze HLF fisher's social networks and map out the network structure of all fishers in the HLF.

[2] This report is based, in part, on the Master's thesis work of Barnes (2012) and resulting manuscript "The influence of ethnic diversity on social network structure in a common-pool resource system: Implications for collaborative management" (Barnes-Mauthe et al. forthcoming)**,** which can both be referenced for further information.

4. Map out the structure of each ethnic community of fishers operating in the HLF.
5. Calculate group-level sociometrics to explore the level bonding, bridging, and linking social network capital for each community of fishers, and for the HLF as a whole.
6. Compare and contrast the level and distribution of social network capital within each community of fishers.
7. Assess the management implications of the level and distribution of social network capital among HLF fishers, paying particular attention to the effects of ethnic diversity.

3. DATA COLLECTION

Unlike many typical SNA studies that use snowball sampling or sample a proportion of a population, the social network data collected here had the specific aim of obtaining the social linkages of the full population of primary decision-makers associated with each vessel currently operating in the HLF. This approach was adopted to overcome the statistical sampling issues commonly associated with random-sample-based data collection methods. Acknowledging that some vessels are run by an owner/operator while some are run by a hired captain, and all owners, captains and owner/operators are involved in various management decisions concerning resource use in the fishery, we defined the population as all active vessel owners, owner/operators, and hired captains.

To assemble the data set, a structured survey designed with the goal of eliciting social and professional relations among fishers in the HLF was used in face-to-face interviews in the native language of each respondent. The survey consisted of three sections. The first section asked general questions about the respondents' experience with fishing, experience in Hawaii and the HLF, and whether or not they frequently discuss or share information regarding different aspects of fishing with other stakeholders in the fishery and how valuable they believe this information exchange is to their fishing success, and how involved each respondent is in decision-making regarding different important aspects of vessel operation and fishing in the HLF. The second part of the survey asked respondents to nominate at least five, but up to ten individuals[3] with whom they share useful information regarding different aspects of fishing in the HLF that they feel is valuable for their fishing success. Respondents were also asked to rate how valuable they feel the information exchange is with each person they have identified. The last part of the survey collected general sociodemographics and specifically, ethnicity. To provide a simple gauge of network consistency, fishers were also asked if their network of contacts identified in this study would have been the same if they were asked five years prior. Please see Appendix A for a copy of the survey used[4].

The data collection began in May of 2011 and was completed in January of 2012. Our response rate was 91.2% for the entire fishery (145 of the 159 owners and operators); 93.3% for fishers in the V-A community (70 of 75 owners and operators), 89.7% for the E-A community (52 of 58 owners and operators), and 88.5% for the K-A community (23 of 26 owners and operators). Though a total of 14 HLF fishers were not surveyed in this study (including four V-A captains), nine of them were identified by at least one, but typically several other fishers, thus making it possible to infer their social network. Therefore, we treat our data as the population of

[3] Here, we refer to respondents as 'fishers' and we use the terms 'individuals' and 'actors' when referring to individuals or groups of individuals identified by respondents (whether they are other fishers, industry leaders, government or management officials, or members of the scientific community).
[4] Please note that only part of the information in the survey was used in this study.

longline fishers rather than a sample, and the five fishers not identified by others we classify as isolated fishers. This classification was corroborated by key informants firmly embedded in the HLF, who claim that these five fishers often fish and stock their vessels in California, only coming to Hawaii periodically, and operating alone when they do.

4. METHODOLOGY

The primary methodology employed in this study is social network analysis (SNA). SNA is a quantitative method that uses sociograms and graph theory to elicit, visualize and analyze social relations and social networks among individuals or groups. By providing a formalized articulation of relational data by explicitly mapping out how individuals are connected, SNA is able to generate a rich set of sociometrics for analysis and extrapolation.

The principal sociometrics used in this study are as follows (also see Barnes 2012, Barnes-Mauthe et al. forthcoming).

1. **Component analysis**—This analysis identifies the number of networks in the dataset that are not connected to each other in any way (Hanneman and Riddle 2005). When a dataset contains separate components, these components are often titled subgroups. The existence of completely distinct subgroups in a network would be an example of the most extreme case of homophily if actors are grouped by a specific attribute, such as ethnicity.

   This analysis is performed to identify the number of sub-networks that exist among HLF fishers, and to determine if a strict homophily effect along ethnic lines is present.

2. **Relational Contingency Table analysis (RCT)**—An analysis that finds the ratio of measured versus expected relations within and between groups, where the expected number of relations equals the relations expected to exist by chance alone in a network of equal size and number of ties (Crona and Bodin 2006).

   This analysis is bit more flexible than the component analysis in identifying homophily, and is used here to examine the extent of ties among HLF fishers that fall within ethnic communities, and that span ethnic communities. This analysis was also used to examine the level and extent of linking social capital ties to outside industry leaders, government or management officials, and members of the scientific community for each ethnic community of fishers.

3. ***K*-core analysis**—A more relaxed way of identifying subgroups and examining the level of cohesion in networks. This analysis identifies parts of the network that form subgroups in a way that each member of the subgroup is connected to at least k number of other actors in the subgroup. The value of k for each group is determined by finding the maximum amount of actors with whom each actor accesses for information, and the lowest reported value of k is used in order to facilitate comparisons across groups (Crowe 2007).

4. **Cut-point analysis**—This analysis determines how many cut-points exist in a network, and can be thought of as a way of determining how loosely connected a network is. Cut-points are nodes or actors in the network whom, if removed, would fragment the network into two or more sub-networks (Hanneman and Riddle 2005).

Following the work of Crowe (2007) and Ramirez-Sanchez and Pinkerton (2009), *k*-cores and cut-points are used to compare each ethnic community of fishers' network structure, and to explore how closely each community network resembles a bonding or bridging network structure. Bonding network structures are classified as either *complete*, where nearly every member is connected to every other member; or *fractional*, where at least two separate densely connected networks exist (Crowe 2007). Bonding networks, such as the complete and fractional networks, are characterized by a high proportion of actors being in the largest *k*-core and a low proportion of cut-points (Crowe 2007). Bridging network structures are classified as either *coalitional*, where there are a variety of densely connected groups that are connected to each other in non-redundant ways; or *bridging*, which is a sparsely connected network (Crowe 2007). Bridging networks are characterized by lower proportions of actors in the largest *k*-core and a higher level of cut-points.

All network data was analyzed in UCINET6's suite of social network programs (Borgatti et al. 2002), and visualized in NetDraw (Borgatti 2002), which provides multi-dimensional scaling/hierarchical clustering techniques that help to generate a rich visual mapping of social networks. Basic statistics were calculated in SPSS Version 20.

5. RESULTS AND ANALYSIS

5.1 HLF Fisher Social Demographics

General HLF fisher sociodemographics are reported in Table 1. First the total number of vessels[5] owned and operated within each community is reported followed by the total number of individuals within each community that were identified by respondents and are included in this study. Currently, the V-A community is the largest, with 56 vessels and 77 identified actors; whereas 41 vessels and 59 actors were identified in the E-A community, and 24 vessels and 26 actors in the K-A community. These results clearly display a growing population of V-A fishers and a dwindling population of K-A fishers compared to previous reports, which found that K-A fishers owned approximately one quarter of HLF vessels, while the remaining vessels were split between E-A and V-A fishers (i.e., Allen et al. forthcoming). Moreover, many members of the K-A community that were contacted for this study reported to us that they had sold their vessel and were no longer operating in the fishery. When this was the case, nearly all vessels had reportedly been sold to a member of the V-A community.

Next, each ethnic community of fishers is broken down by respective titles, which classify their involvement or role in the fishery. While more than half of E-A and V-A fishers are hired captains (54% and 51% of the total population, respectively), 58% of K-A fishers are owner/operators. Some vessel owners also classified as industry leaders (9 in the E-A community, 1 in the K-A community, and 6 in the V-A community). These individuals own at least one vessel currently operating in the fishery, but also play an active role in the industry as,

[5] To our knowledge, there were four additional vessels officially in operation within the HLF at the time of this project that were not included in our analysis; one from the E-A community, and three from the V-A community; which were reportedly owned and operated by isolated fishers.

for example, a supply store owner or a Hawaii Longline Association (HLA) official. Many fishers identified ties to industry leaders who are also vessel owners, and to industry leaders who are not fishers themselves but are essentially accessible to all HLF fishers (which is reported and discussed in section 5.4). However, V-A fishers also identified ties to three additional industry leaders who are firmly integrated in the V-A fishing community and are essentially not accessible to all HLF fishers; thus, these individuals were classified as part of the V-A fishing community. These individuals included two family members of a V-A supply store owner, and an employee of a different V-A supply store.

Table 1 also includes the mean, minimum, maximum and standard deviation of the following characteristics: age, years fishing, years in Hawaii, years in the HLF, and total number of network ties. Statistical difference in means between groups was calculated for each variable using the LSD and Tukey statistical tests. The average age of fishers in the E-A and V-A community is 51 years, while the average age of K-A fishers is 57. The minimum age reported within the K-A community was 39, compared to 25 and 29 within the E-A and V-A communities (respectively). The higher mean and minimum age within the K-A community may be one explanation for the decreasing population of K-A fishers—as K-A fishers begin to retire, there may be an absence of younger individuals within their community willing or able to take up the profession. This hypothesis is corroborated by recent ethnographic research done on the HLF, which reported that K-A fishers are less likely to encourage their children to become fishers themselves (Allen et al. forthcoming).

K-A fishers also reported a higher mean for the number of years spent fishing (28.85 years, with a min of 18 years), though the mean was not statistically different from the E-A community. Comparatively, V-A fishers reported a mean of 17.19 years spent fishing. K-A fishers also reported to have been in Hawaii longer than other fishers, with a mean of 28.85 years and little variation. In comparison, V-A fishers reported a mean of 19.46 years in Hawaii, while E-A fishers reported a mean of 15.09 years in Hawaii. K-A fishers also reported being in the HLF for the longest, with a mean of 27.15 years, while E-A and V-A fishers reported having been involved in the HLF on average for 14.94 and 16.90 years (respectively). Considering the older age of K-A fishers, higher values found for years fishing, years in Hawaii, and years in the HLF were somewhat expected.

The level of education among fishers also differs among ethnic communities. All fishers in the E-A community, 85% of K-A fishers and 33% of V-A fishers reported an education level of high school or above. V-A fishers reported the highest percentage of their population completing a bachelor's degree or higher (14%), though E-A fishers reported a similar percentage of their population also attaining this level of education (13%). No K-A fishers reported having completed a bachelor's degree, though not all fishers chose to provide an answer to this question. The majority of V-A fishers (65%) reported an elementary school level of education, while the majority of K-A fishers reported a high school level (80%), and the majority of E-A fishers reported either high school (48%) or some college (40%).

Lastly, Table 1 reports the mean number of network ties per actor. Members of the E-A and K-A community were found to have a similar average number of ties per actor (6.19 and 6.04, respectively), while V-A fishers were found to have on average 12.74 ties per actor. This will be discussed in further detail in the following sections.

Table 1. HLF fisher sociodemographics.

	Description	E-A	K-A	V-A
# Vessels		41	24	56
N		59	26	77
Title	Owner	9 (15%)	4 (15%)	16 (21%)
	Captain	32 (54%)	6 (23%)	39 (51%)
	Owner/Operator	9 (15%)	15 (58%)	13 (17%)
	Industry Leader	0 (0%)	0 (0%)	3 (4%)
	Owner/Industry Leader	9 (15%)	1 (4%)	6 (8%)
Age	*M*	51.62[a]	57.00[b]	51.39[a]
	min	25	39	29
	max	72	68	72
	SD	10.902	8.092	9.512
Education[1]	None	0 (0%)	1 (5%)	1 (1%)
	Elementary School	0 (0%)	2 (10%)	45 (65%)
	High School	23 (48%)	16 (80%)	8 (12%)
	Some College	19 (40%)	1 (5%)	5 (7%)
	Bachelor's Degree or Higher	6 (13%)	0 (0%)	10 (14%)
Yrs fishing	*M*	31.40[a]	28.85[a]	17.19[b]
	min	7	18	1
	max	54	46	29
	SD	10.588	6.877	7.057
Yrs in HI	*M*	15.09[a]	28.55[b]	19.46[c]
	min	0	18	0
	max	67	37	33
	SD	14.923	4.828	5.492
Yrs in the HLF	*M*	14.94[a]	27.15[b]	16.90[a]
	min	1	18	1
	max	32	35	25
	SD	8.603	4.934	6.744
No. of network ties per actor	*M*	6.19[a]	6.04[a]	12.74[b]
	min	1	2	2
	max	18	13	53
	SD	4.265	2.793	7.428

Note: Similar superscript describes homogenous subsets using the least significant difference (LSD) & Tukey test at the 5% level of significance.

[1]A small number of respondents chose not to answer this question; thus, percentages reflect only the respondents who chose to provide an answer.

In order to gauge the level of involvement of each respondent in decision-making regarding important issues related to fishing in the HLF, we asked each fisher if they were involved in making decisions regarding the following topics: fish activity, hiring, site catch, regulations, weather, vessel technology/maintenance, fishing gear, and bycatch. The results are presented in Table 2 as the proportion of each type of actor (i.e., owner, captain, owner/operator and owner/industry leader) within each ethnic community that reported being involved in decisions for each topic category. We also summed the proportions in each topic category for each type of actor to provide an overall indicator of involvement in decision-making regarding all topics, which is presented in the final right column of Table 2.

Table 2. Proportion of HLF fishers involved in decision-making regarding various topics.

	Fish Activity	Hiring	Site Catch	Regulations	Weather	Vessel Technology/ Maintenance	Gear	Bycatch	Decision Making Indicator*
E-A Fishers									
Owners	.50	1.00	.50	1.00	.33	1.00	.50	.67	**5.5**
Captains	1.00	.73	1.00	.73	1.00	.88	.96	.92	**7.2**
Owner/Op.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.0**
Owner/Ind. Leaders	.67	1.00	.56	1.00	.67	1.00	.89	.89	**6.7**
K-A Fishers									
Owners	1.00	1.00	1.00	.67	1.00	1.00	1.00	.67	**7.3**
Captains	1.00	.25	1.00	.25	.75	.75	.75	.50	**5.3**
Owner/Op.	1.00	.79	1.00	.79	.93	.86	.79	.71	**6.7**
Owner/Ind. Leaders	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.0**
V-A Fishers									
Owners	.94	1.00	.94	1.00	.94	1.00	1.00	.94	**7.8**
Captains	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**8.0**
Owner/Op.	1.00	1.00	1.00	1.00	1.00	.92	1.00	1.00	**7.9**
Owner/Ind. Leaders	.80	1.00	.80	1.00	.80	1.00	.80	.80	**7.0**

*Note: All proportions are summed in the last column to provide an indicator of overall involvement in decision-making for each type of actor, where a sum of 8.0 represents the highest involvement in decision-making concerning these respective topics.

Owners, captains, owner/operators and owner/industry leaders all reported various levels of involvement in each category, and within each ethnic community there is variation regarding who might be considered the primary decision-maker for HLF vessels. For example, owner/operators reported the highest level of involvement in decision-making for all topics in the E-A community; whereas owner/industry leaders reported the highest level of involvement in all categories in the K-A community; and captains reported the highest level of involvement in all categories in the V-A community (with owner/operators at a close second). However, variation regarding decision-making also exists within each ethnic community regarding different topic categories. For example, regarding regulations, all vessel owners and owners who are also industry leaders reported being involved in decision-making in the E-A and V-A communities. Comparatively, all vessel owners who are also industry leaders in the K-A community also reported being involved in decision-making regarding regulations; however, only 67% of K-A vessel owners reported being involved in decision-making regarding this topic.

The information provided in Table 2 on decision making regarding specific topics could be useful for fishery managers when considering who to contact or approach regarding various HLF management and regulatory concerns. It appears that within each ethnic community of fishers, it may be more effective to contact certain individuals over others depending on the topic of interest. For example, within the E-A community, our results suggest that issues related to fishing gear may be more efficiently handled by approaching those who operate the HLF fishing vessels (captains and owner/operators) rather than approaching solely vessel owners; whereas the population of vessel owners appears to be an appropriate audience for gear-related issues within the K-A and V-A communities.

5.2 Characterizing HLF Information Sharing

Responses to our general questions about, (1) the frequency that fishers share useful information about fishing with other relevant stakeholders within their social network, and (2) how valuable this information exchange is to their overall success in the fishery are depicted

graphically in Figures 1 and 2. Figure 1 shows that the majority of all fishers reported that they share information 1-3 times a week (71% of E-A fishers, 86% of K-A fishers, and 94% of V-A fishers). 21% of E-A fishers reported sharing information less frequently at 1-3 times a month, while 5% of K-A fishers and the remaining 6% of V-A fishers also reported doing so. Lastly, 9% of K-A fishers and 8% of E-A fishers reported sharing information only 1-3 times a year.

Figure 2 shows that the majority of V-A fishers reported that sharing information with other relevant stakeholders within their social network is very important to their overall success in the fishery (89%), while 9% reported it was important, 1% reported it was somewhat important, and 1% reported it was not important. Comparatively, 38% and 45% of E-A and V-A fishers reported that sharing information with other relevant stakeholders within their social network was very important, while 31% and 41% reported it was important, respectively. 23% of E-A fishers and the remaining 14% of K-A fishers reported it was somewhat important, while the remaining 8% of E-A fishers reported that sharing information with other relevant stakeholders within their social network was not important to their overall success in the fishery.

As briefly mentioned previously, V-A fishers also reported the highest number of ties on average per individual, which is depicted graphically in Figure 3. Considering the high average number of ties held by V-A fishers compared to the average number of ties held by other fishers, it is not surprising that V-A fishers also reported sharing information more frequently within their network and placing a higher level of importance on those information exchanges. Although the majority of fishers reported that sharing information within their social network was either very important or important, it's possible the difference between these two categories was not conceptualized in the same manner by all respondents. Regardless, the main take-away may be that the majority of HLF fishers find that sharing information within their fishery-related social network is important for their overall success in the fishery.

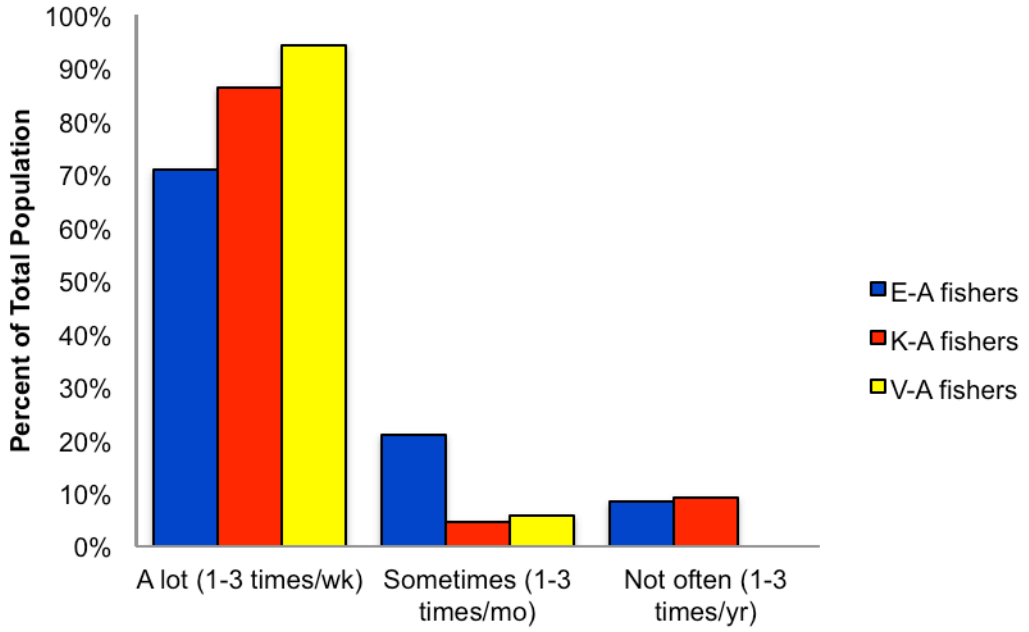

Figure 1. How frequently do HLF fishers share information within their social network?

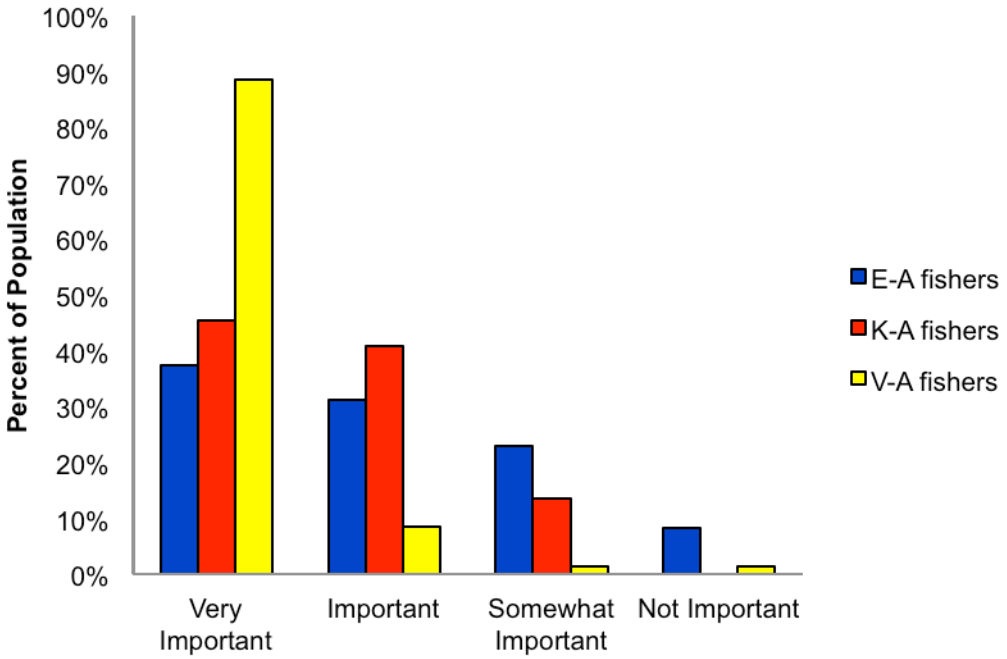

Figure 2. How important is information sharing to HLF fishers?

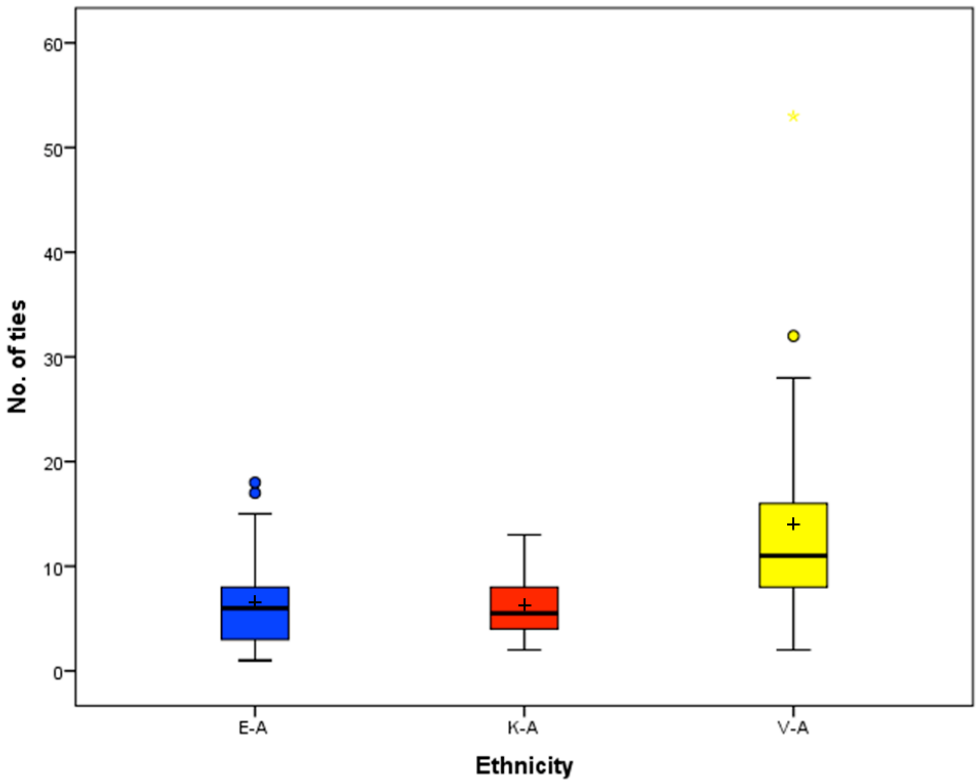

Figure 3. The distribution of total number of ties per actor by ethnicity, adapted from Barnes-Mauthe et al. (forthcoming). Lines represent medians; plus signs represent means; circles represent outliers and stars represent extreme outliers.

To determine if attributes other than ethnicity are related to the number of network ties per actor, such as years in Hawaii or years in the HLF, we ran an analysis of covariance on number of ties. The results, presented in Table 3, show that aside from ethnicity, which is significant at the 1% level, the only other significant attribute is title (also significant at the 1% level), which is represented graphically in Figure 4. Vessel owners who are also industry leaders have the highest number of ties on average, followed by industry leaders, owner/operators, captains, and lastly, vessel owners. Industry leaders and vessel owners who are also industry leaders may have the highest number of ties on average due to their high level of involvement and expertise in the industry—it's highly probable that these individuals are sought out by others who may have questions or need advice. Also, some vessel owners who are not also industry leaders, particularly within the E-A community, live on the mainland U.S., only coming to Hawaii at times when their vessel is in port. This may be one contributing factor causing vessel owners to have the lowest average number of ties compared to the rest of HLF fishers.

Table 3. Analysis of covariance on number of ties per actor.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1883.699[a]	5	376.740	12.183	.000
Intercept	7.181	1	7.181	.232	.631
Ethnicity***	1122.803	1	1122.803	36.309	.000
Title***	716.133	1	716.133	23.158	.000
Age	4.774	1	4.774	.154	.695
Education	.596	1	.596	.019	.890
Exp.Value	17.469	1	17.469	.565	.454
Error	4020.066	130	30.924		
Total	19988.000	136			
Corrected Total	5903.765	135			

a. R Squared = .319 (Adjusted R^2= .293)
***Significant at the .000 level

Lastly, when fishers identified specific individuals with whom they shared information that they felt was important to their overall success in the fishery, they were asked to check what topics they discussed with each individual. Thus, we were able to provide a brief characterizkation on the type of information that fishers exchange within their social network[6], which is presented in Table 4 as the percentage of total ties reported in each ethnic community and for all fishers who reported sharing information about each respective fishing topic.

[6] This includes ties to industry leaders, government and management officials, and members of the scientific community.

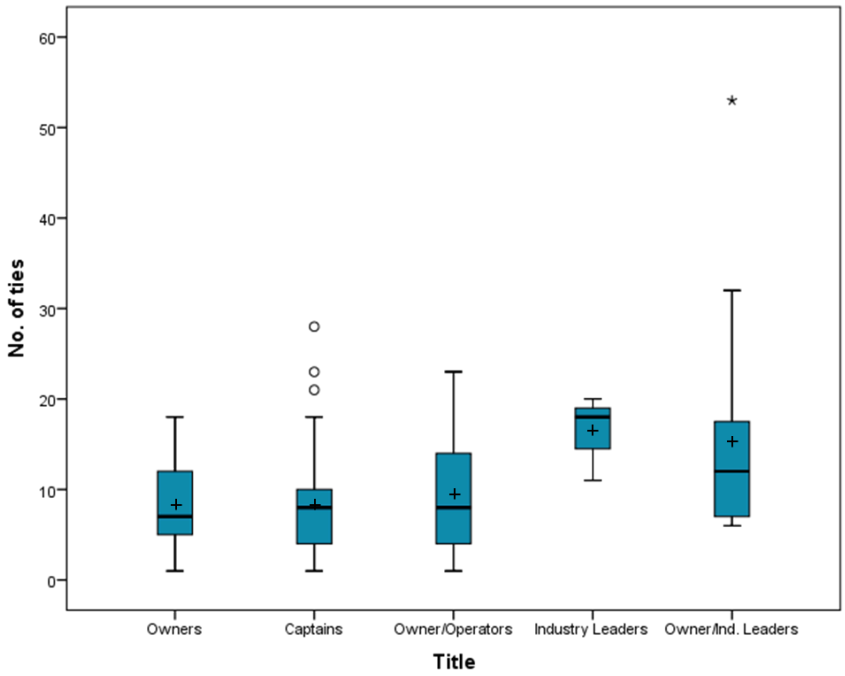

Figure 4. The distribution of total number of ties per actor by title. Lines represent medians; plus signs represent means; circles represent outliers and stars represent extreme outliers.

According to our results, fish activity is the most frequently discussed topic by all fishers. Here, fish activity refers to the current behavior of the target species, or more commonly stated as "what the fish are up to." Fish activity, as the most frequently discussed topic, is followed by gear, regulations, bycatch, hiring, vessel technology and maintenance, site catch, and weather; though there are variations between ethnic communities. For example, though all fishers selected fish activity as the topic discussed most frequently, the next most frequent topic was different for each ethnic community (site catch, weather, and regulations for the E-A, K-A and V-A communities, respectively). The topic selected the least was hiring for E-A fishers (55% of all reported ties), bycatch for K-A fishers (27% of all reported ties), and site catch for V-A fishers (55% of all reported ties). Regulations were selected as a topic of conversation for 74%, 45%, and 97% of all reported ties for the E-A, K-A and V-A fishers, respectively; while bycatch was selected as a topic discussed for 65%, 27%, and 97% of all reported ties for E-A, K-A and V-A fishers, respectively. This information concerning the prevalence of various topics in discussions among fishers is discussed further in the context of each ethnic community's social network structure in sections 5.4 and 5.5.

Table 4. What type of information do fishers exchange?

	Fish Activity	Gear	Regulations	By-catch	Hiring	Tech./Vessel Maint.	Site Catch	Weather
E-A Fishers	89%	70%	74%	65%	55%	72%	83%	64%
K-A Fishers	99%	72%	45%	27%	41%	67%	95%	89%
V-A Fishers	98%	95%	97%	93%	90%	68%	55%	57%
All Fishers	96%	86%	86%	80%	76%	69%	66%	61%

Note: Percentage of the total number of ties for each ethnic community and for all HLF fishers by which each respective fishing topic is discussed.

5.3 HLF Network Characteristics

Figure 5 depicts the entire HLF network including all ties identified as being either valuable or very valuable, including ties to industry leaders, management or government officials, and the scientific community. In this graph, each node was placed by an algorithm that uses iterative fitting to place points on the shortest path length closest to each other. The node repulsion option was also used, which separates objects that would otherwise be placed very close together, which makes the graph a bit easier to read without losing important information on node placement. Ethnic affiliation was not determined for industry leaders that were not also fishers, for management and government officials, or members of the scientific community since the focus was on the ethnic diversity of the fishers themselves. For the rest of this report, all graphs will be depicted using the above criteria.

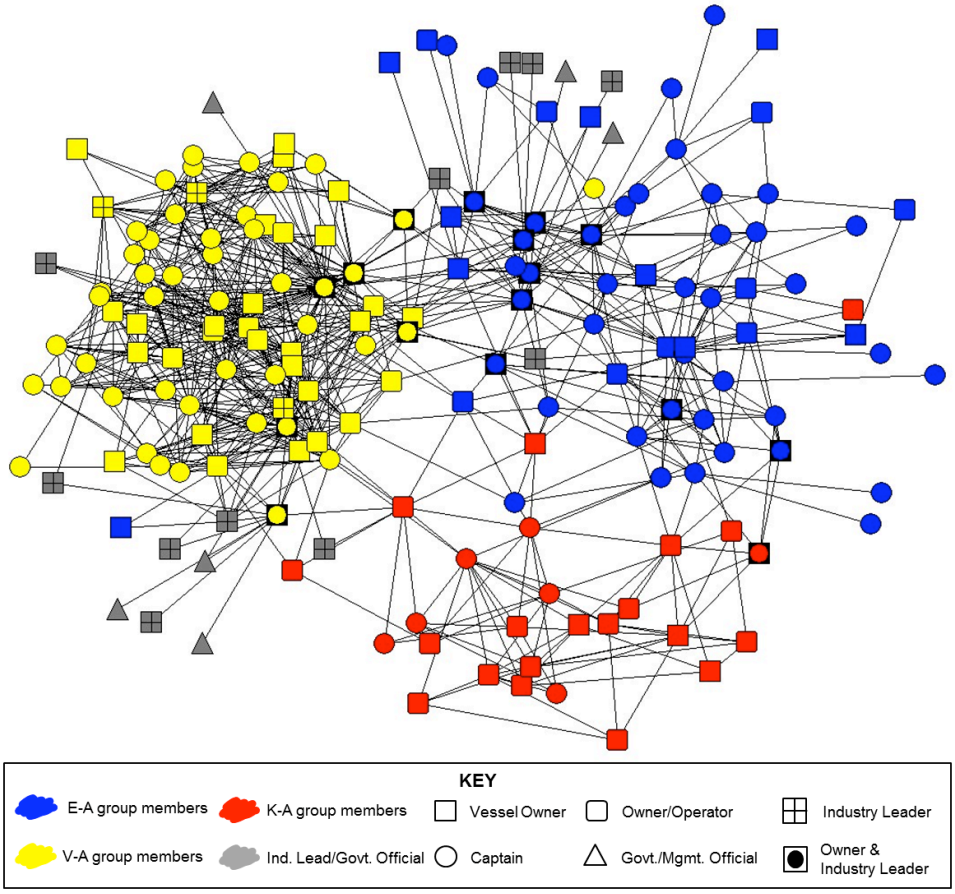

Figure 5. HLF network configuration, adapted from Barnes-Mauthe et al. (forthcoming). The network includes all relations identified by the population of vessel owners and operators in the HLF. Nodes (representing actors) with the smallest path lengths to each other are placed closest together by an algorithm that uses iterative fitting. Node color and shape represent the actor's title and ethnicity affiliation as described in the key.

Looking at the overall network structure of the HLF depicted in Figure 5, a few interesting findings emerge. The first observation is that all nodes in the overall network are connected to one network structure; meaning that every fisher is somehow connected to every other fisher

(though it may be through a very indirect relationship). This observation is verified by the component analysis, which classifies all nodes as falling within a single component (Table 6, discussed later). Thus, no group of fishers is completely fragmented or isolated from any other group. Another thing one may notice is that the nodes seem to be placed in groups determined by ethnic affiliation, and there appears to be many more ties within groups than between groups. This suggests a homophily effect, though not quite as extreme as it would be if the groups had formed completely separate components.

To further explore the extent of the potential homophily effect we examine the results of the RCT analysis, which are presented in Table 5 as the proportion of observed vs. expected number of relations both within and between groups. Within group relations are significantly higher than between group relations, which the node placement in Figure 5 certainly suggests. K-A fishers have 4 times the amount of ties within their community than one might expect in a network of the same size and number of ties under a model of independence; whereas V-A fishers have 3.25 times the number of ties within their community, and E-A fishers have 1.91 times the number of ties within their community than one might expect. Ties between E-A and K-A fishers reported by E-A fishers have the highest proportion between groups (0.37), though this is still well below the expected number of relations between these two communities. Moreover, K-A fishers reported only a proportion of only 0.07 of the expected number of ties with members of the E-A community. Significantly, no ties between the V-A and K-A community were reported by V-A fishers. Lastly, ties between the E-A and V-A community are also well below the expected proportion, further confirming the existence of a homophily effect along ethnic lines among HLF fishers.

Table 5. Relational contingency table analysis results, adapted from Barnes-Mauthe et al. (forthcoming)[1]. Values are reported as the proportion of observed vs. expected number of ties within and between groups.

	E-A	**K-A**	**V-A**	**Ind. Leaders, Govt/Mgmt Officials, Scientific Community**
E-A	1.91	0.37	0.13	0.35
K-A	0.07	4.00	0.11	0.08
V-A	0.09	0.00	3.25	0.98

[1]All values are significant at the 0.001 level.

Homophily based on ethnic association among fishers was expected based on previous research (i.e., Allen et al. forthcoming); nonetheless, it has important implications for management and the overall adaptability of the fishery. Homophily in networks can have substantial impacts on the quality and quantity of information that different actors receive based on where they are located within the network, and can substantially affect the attitudes and beliefs different actors form as well as the interactions they experience (McPherson et al. 2001). Moreover, homophily and the resulting separation of actors can be responsible for an "us-them" attitude (Krackhardt and Stern 1988) that can pose challenges to collaboration for effective resource management. Fishers were not explicitly asked to express their attitudes concerning fishers of the different ethnic communities when the field work was being completed for this study. However, while speaking with respondents during this project it was not uncommon for them to speak openly about fishers from each ethnic background as being part of separate group or community, suggesting that an "us-them" attitude does exist in the HLF to a certain extent.

Nonetheless, links across ethnic fisher communities do exist, and these ties may have the potential to build trust across ethnic divides and bring subgroups together behind a common goal under the right circumstances.

5.4 Linking Social Capital

Results regarding linking social capital ties can also be viewed in Table 5 by examining the final right column that reports the proportion of observed vs. expected number of relations between each ethnic community of fishers and industry leaders, management and government officials, and members of the scientific community (grouped together for this analysis). V-A fishers reported 98% of the ties of this nature that one would expect under a model of independence, while E-A fishers reported 35% and K-A fishers reported 8%.

Of particular importance is the strikingly low proportion of linking ties reported by K-A fishers, and in fact, the proportion of 0.08 represents only one single tie among the whole community (see Figure 5 for a depiction of this tie, which is in the lower middle section of the graph). These results imply that K-A fishers may be fragmented in regards to linking social capital, in addition to being somewhat fragmented from the V-A community, which could certainly be obstructing stakeholder cooperation and collaboration among HLF fishers. This also suggests that the interests of K-A fishers may not be adequately represented in the management and policy arena, and that K-A fishers may be somewhat isolated from certain resources and information such as technological innovations and scientific knowledge. Considering K-A fishers reported the lowest percentage of total ties for both bycatch (27%) and regulations (45%) as a discussion topic, it's possible that K-A fishers lack access to updated information on these topics due to the low level of linking social capital ties to industry leaders and other key individuals in the management and policy arena. On a related note, there was only one owner/industry leader identified within the K-A community.

In contrast, the V-A community reported more ties to industry leaders, management or government officials, and members of the scientific community than any other group in our analysis, reporting 98% of expected ties. These results differ from previous work done on linking social capital among ethnically diverse resource users (Romani 2003), which suggested that ethnic minority groups[7] tend to have less access to extension services in natural resource settings, which implies lower levels of linking social capital. Our findings here are certainly interesting for a variety of reasons. One reason is due to the fact that members of the E-A community rather than the V-A community currently occupy the majority of positions in the Hawaii Longline Association (HLA), which were classified as industry leaders in the present study. The HLA is a trade association, which works to represent the HLF, and every vessel selling fish to the auction in Honolulu is required to join the HLA and pay dues of two cents per pound of fish sales. The HLA has a functioning body of leadership as well as fisher representatives that act as board members, and regular meetings are held to discuss important issues regarding the fishery as well as how the member dues will be used. Though all fishers are invited to the meetings, most fishers are unable to attend due to often being at sea when the meetings are held. This makes it important for fishers to have a board member present at HLA meetings to ensure their interests are represented and that information regarding fishery policy and management is disseminated back to each fishing community.

[7] Ethnic minority, in this case, refers to groups that are a relative minority in their locality, not necessarily in the resource system itself.

In the survey instrument of the present study, respondents were asked if they were a member of HLA and if they were presently a board member or officer in the association, or if they had been in the past. Results show that 100% (77) of V-A fishers reported being a member of the HLA, but only 4% (3) reported being a board member or officer either currently or in the past; while 88% (52) of E-A fishers reported being members of HLA, and 17% (9) of them reported holding a position as a board member or officer either currently or in the past. In regards to the K-A community, only 72% (18) reported being a member of HLA, while only one of those members reported serving as a board member or officer.

With such a comparatively high proportion of E-A community members having direct involvement with the HLA, it is interesting to note that the V-A fishers reported a much higher level of linking ties. One explanation for this is that while some members of the E-A community reported having ties to officials involved with HLA as well as supply store owners, gear maintenance and technology experts, fish auction officials, and government or management officials; many of these ties were identified by only a single fisher in the E-A community rather than by multiple fishers. In contrast, members of the V-A community reported similar ties to the same type of actors listed above, but also identified ties to members of the coast guard, customs and border protection, and crew agents; and in many cases more than one V-A fisher identified ties to these actors. V-A fishers also identified ties to industry leaders involved with VAK Fisheries, which was originally developed as a cooperative to expand business services to all Hawaii's longline vessels. Though the cooperative sought to attract members from all fisher communities, according to our survey membership is largely made up V-A fishers, with only one member of the E-A community and three members of the K-A community reporting an affiliation with VAK. Nonetheless, VAK members are afforded resources and ties to government and management officials via the organization, which not only aids in restocking and refueling vessels when they arrive in port, but also helps fishers with business filings, permits and licenses; particularly for those with limited English speaking and reading skills (Lu and Nguyen 2008). Therefore, VAK Fisheries managers and affiliates were classified as industry leaders for the purposes of this study (as were other supply store owners and workers who operate in a similar fashion) and ties to managers and affiliates of VAK were reported solely in the V-A community.

5.5 Bonding and Bridging Social Capital

Table 6 provides a descriptive summary of group level characteristics concerning bonding and bridging social capital found for the total HLF network and for each ethnic community of fishers. The table includes the number of actors and ties within each group, and the average outdegree (number of ties reported by respondents) of each group. This is followed by the number of actors in the largest component, as well as the number of isolated fishers in each community. Following previous work (i.e., Crowe 2007, Ramirez-Sanchez and Pinkerton 2009), isolated fishers were reported, but not included in group analyses. Results of the *k*-core and cut-point analyses are also offered in Table 6, which were used to classify each community as having either a bonding or bridging network structure according to Crowe's (2007) framework described in section 4.

Table 6. Summary of group level network characteristics, adapted from Barnes-Mauthe et al. (forthcoming).

	Entire HLF	E-A	K-A	V-A
HLF network data				
Total actors	179	79	33	94
No. of ties	895	229	83	581
Fishers-only network[1]				
Total actors	---	60	25	77
No. of ties	---	189	73	542
Avg. outdegree	5.00	3.26	2.92	7.04
No. of components	1	2	1	1
Largest component				
Number of actors	179	60	25	77
Isolated actors	5	1	0	0
Indicators of network cohesion				
Largest k-core	8	4	4	8
No. of actors in largest k-core	48	34	16	48
Proportion in 4-core and higher	0.75	0.58	0.64	0.99
Indicators of structural holes				
No. of cut-points	10	7	0	1
No. of blocks	20	11	1	2
Proportion of cut-points to total points	0.06	0.09	0.00	0.01
Estimated network configuration	Coalitional	Bridging	Complete/ Bonding	Complete/ Bonding

[1]Fishers-only network, which was used to calculate all ethnic group metrics, consists of ethnic group members only and does not include industry leaders, government or management officials, and members of the scientific community.

Overall, the HLF network was classified as a coalitional structure. This classification was largely made due to the observed division along ethnic lines (see Figure 5), as well as the moderate rate of cut-points in the HLF network (0.06). As previously stated, the number of cut-points equals the number of actors, whom, if removed, would fragment the network into two or more completely separate networks. Though the HLF network has a high order of *k*-core, where k = 8, which is an indicator of network cohesion, all of the 48 fishers in this order are from the V-A community (see the V-A community *k*-core results three columns over), which had a strong impact on the *k*-core analysis for the HLF network as a whole.

Coalitional networks are a type of bridging network; thus, the bridging characteristic of the HLF network may be facilitating access to external resources and diverse knowledge for HLF fishers, which is thought to increase the overall adaptability of natural resource systems (see Sandström and Rova 2010). The central idea is that novel information flows to actors through weak ties rather than strong ties because close friends tend to have the same information and knowledge, whereas acquaintances can connect individuals to a wider world (Granovetter 2005). Though there is an overall lack of bonding ties across groups inherent in coalitional structures, dense bonding groups connected to each other in non-redundant ways can form within coalitional structures, wherein a level of trust and norms is possible (Crowe 2007). However, in this case, the ability for trust and norms to develop across groups is likely to be impacted by the observed homophily effect. Indeed, a low level of trust across ethnic groups in this fishery was recently reported by Allen and colleagues (forthcoming). Perceptions of distrust concerning fishers in different ethnic groups were also expressed by a number of individuals who participated in this study.

Fishers-only networks were used to calculate all metrics at the ethnic community level, since including ties to industry leaders, government and management officials, and members of the scientific community would have skewed the results of community level metrics. As reported in Table 6, the E-A community was classified as a bridging structure, whereas the K-A community and the V-A community were classified as complete or bonding structures. Depictions of each community network including all reported ties and fishers-only networks can be found in Figures 6, 7 and 8. The difference between the bonding and bridging classification is most obvious when comparing the results of the E-A and V-A community, where the E-A community only has 0.58 of its members in the 4-core and higher order and the V-A community has 0.99 of its members in the 4-core and higher order (Table 6). Moreover, the E-A community has 7 cut-points and 11 blocks, meaning that if these 7 actors were removed from the E-A community, the E-A network would be fragmented into 11 completely separate networks, while the V-A community only has 1 cut-point and 2 blocks.

The bridging nature of the E-A community can be seen when viewing this network in Figure 6, which shows that there are quite a few actors who are only sparsely connected to the overall network; while the bonding nature of the V-A community is easily detected when viewing the V-A fishers' network in Figure 7, which is made up of very densely connected actors. These findings support previous ethnographic research done on the HLF, which inquired about the social networks of the fishery via semi-structured interviews as a part of a larger research project. In this study, Allen et al. (forthcoming) found that although some members of the E-A community are closely tied with a small unit of others, some operate independently, and many feel that there is a lack of solidarity within their community. This was corroborated by a handful of E-A respondents in the current study who mentioned that most E-A fishers were quite independent and considered aloud whether they might benefit as a group from increased cooperation. Allen and colleagues (forthcoming) also found that V-A fishers demonstrated strong kinship within their community, with many immediate and extended family members owning and/or working together on a number of vessels or assisting others when needed (Allen et al. forthcoming). This observed solidarity within the V-A community is certainly supported by the tight bonding network structure among V-A fishers found here.

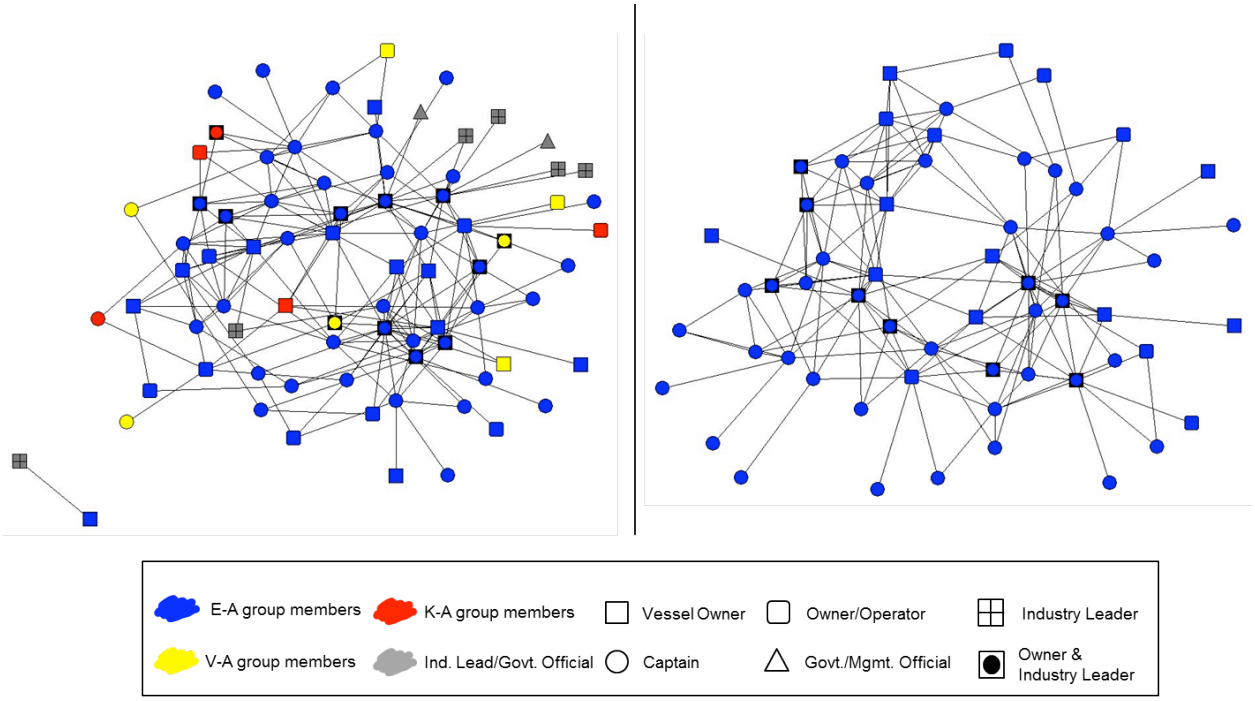

Figure 6. European-American **(**E-A) network configurations generated in NetDraw (Borgatti 2002). Network depictions include all ties identified (top), and ties between members of the E-A community only (bottom). Nodes (representing actors) with the smallest path lengths to each other are placed closest together. Node color and shape represent the actor's title and ethnicity affiliation as described in the key.

Comparatively, the K-A community (Figure 8) has no identifiable cut-points, which was a major factor in its classification. Although there are only 64% of its members included in the highest order of *k*-core in this analysis, there is reason to believe that many more ties exist in this community. In general, K-A fishers were hesitant about sharing information about their relationships when participating in the survey and often times would report only a few ties, afterwards stating that they didn't feel comfortable giving more information. This is consistent with previous research, which found that members of the K-A community were often reluctant to share information (Allen et al. forthcoming). However, the current analysis of the K-A community network structure contrasts with the previous inquiry into fishers' social networks by Allen et al. (forthcoming), which found that there were two separate social networks of individuals in the K-A community. As shown in Figure 8, members of the K-A community currently form a single network, which is corroborated by our group level metrics (Table 6) that classify the K-A community as one single, cohesive component with no identifiable cut-points. One possible explanation for this observed difference in social structure is that members of one of the two previously observed groups may have recently decided to exit the fishery, potentially causing the remaining fishers to form ties with other K-A fishers.

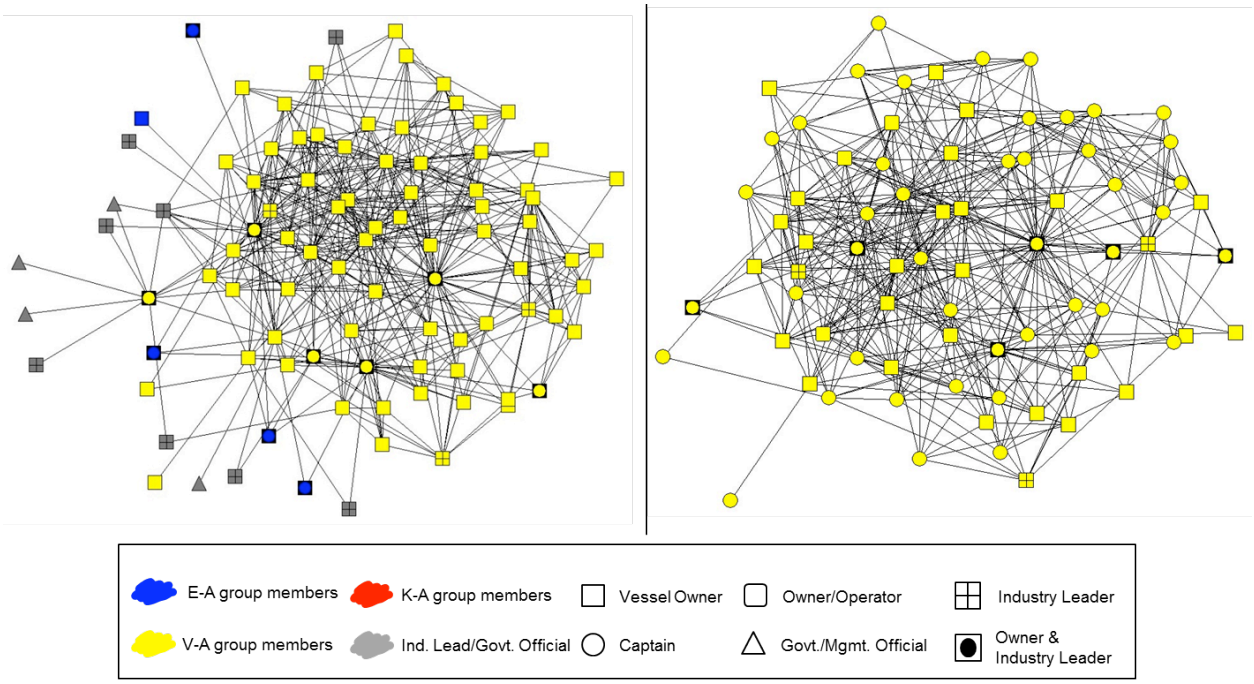

Figure 7. Vietnamese-American (V-A) network configurations generated in NetDraw (Borgatti 2002). Network depictions include all ties identified (top), and ties between members of the V-A community only (bottom). Nodes (representing actors) with the smallest path lengths to each other are placed closest together. Node color and shape represent the actor's title and ethnicity affiliation as described in the key.

5.6 Consistency of Network Structure

One commonly cited pitfall of utilizing SNA to analyze social phenomenon is that network depictions can be quite static in nature, representing a sort of snapshot in time; when in reality relationships are constantly evolving—new ties can be formed and old ties can be broken as time passes (see Bodin and Prell 2011). Addressing this pitfall would call for the same analysis to be completed at different points in time in order to analyze, and control for, potential changes in the network; however, lack of time and resources have often made this impossible under most circumstances.

In an attempt to provide a simple gauge of consistency of the HLF networks analyzed here, we asked all survey respondents to report whether their network they were describing to us for the present study had changed within the past five years, and if so, to what extent. Fishers were asked to answer from the following options; if asked five years prior, their network would have been: (1) exactly the same, (2) mostly the same, (3) somewhat the same, or (4) completely different. Results concerning this inquiry are presented in Table 7 as the percentage of each ethnic community of fishers and all HLF fishers who answered 1-4.

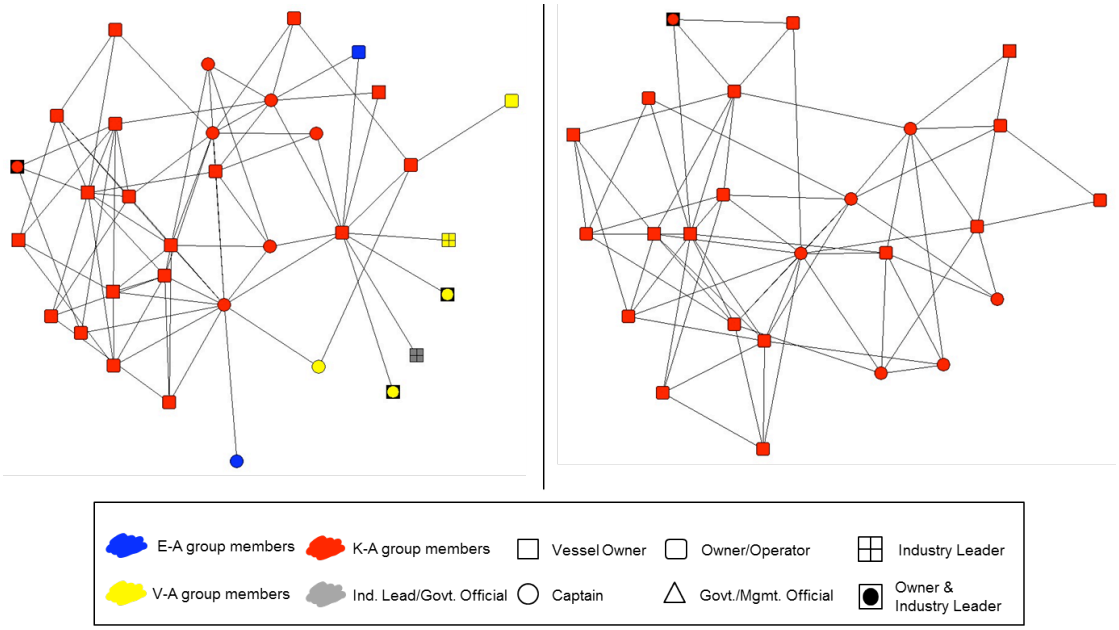

Figure 8. Korean-American (K-A) network configurations generated in NetDraw (Borgatti 2002). Network depictions include all ties identified (top), and ties between members of the K-A community only (bottom). Nodes (representing actors) with the smallest path lengths to each other are placed closest together. Node color and shape represent the actor's title and ethnicity affiliation as described in the key.

Table 7. Network consistency as the percentage of fishers who reported their network was exactly the same, mostly the same, somewhat the same, and completely different from 5 years prior.

	E-A	K-A	V-A	All HLF Fishers
Exactly the same	47%	25%	81%	62%
Mostly the same	44%	55%	17%	32%
Somewhat the same	7%	20%	1%	6%
Completely different	2%	0%	0%	1%

As a whole, the majority of all HLF fishers reported that their network was exactly the same five years prior (62%), while the majority of the remainder reported that it was mostly the same (32%). Only 1% reported that their network was completely different, while the remaining 6% reported it was only somewhat the same. Within ethnic communities, 81% of V-A fishers reported their network was exactly the same, while 47% of E-A fishers and only 25% of K-A fishers reported their network was exactly the same. A higher percentage of K-A fishers also reported that their network was only somewhat the same (20%), compared to E-A fishers (7%) and V-A fishers (7%); though no fishers from the K-A community reported that their network was completely different. It's possible that there is more variation regarding network consistency within the K-A community due to the older age and decreasing population of K-A fishers—as more K-A fishers grow older, it's probable that actors who were previously part of many K-A fisher's social network have retired and exited the fishery, thus altering the social structure of the remaining K-A fishing community.

6. DISCUSSION

With increasing fisheries decline on a global scale coupled with the looming threat of climate change impacts on fish stock abundance and distribution, there is a need for effective management strategies that can increase the sustainability of fisheries resources and their supporting ecosystems. From a management perspective, the structure of fisher's social networks and the existence or absence of social capital can affect the diffusion of information and innovation and impact attitudes toward fishery policy among individual fishers; all of which can play a role in the effectiveness of management initiatives (Mueller et al. 2008). Thus, characterizing the social network structure of fishers and gaining an understanding of the factors influencing the level and distribution of social network capital among them may help to enable more effective resource governance and enhance long-term sustainability.

Here, we analyzed information sharing and fisher's social networks in Hawaii's longline fishery, which is currently characterized by ethnic diversity among individual fishers. We found significant heterogeneity concerning the size of fisher's social networks—some fishers have a very large social network (e.g., over 60 ties were reported for one individual), while others are relatively small. Despite this variation, the majority of all fishers reported sharing information fairly frequently (1-3 times a week), while also reporting that this information exchange was important to their success in the fishery. As a group, V-A fishers reported the highest number of social network ties per individual and the highest frequency of information exchange, while also placing a higher level of importance on sharing information within their social networks.

6.1 Homophily Across Ethnic Groups

Our network analysis revealed that HLF fishers primarily share information with others of similar ethnic backgrounds, and a homophily effect exists along ethnic lines. This suggests there may be a lack of trust, reciprocity, and consensus regarding social norms across ethnic divides, which can be particularly important features of effective resource management in pelagic marine fisheries due to offshore enforcement capacity generally being low (Grafton 2005). The lack of bonding social capital across the HLF as a whole is also likely to be negatively impacting the potential for consensus building and conflict resolution among fishers, which can also be essential features of successful fishery management.

The communication barrier between ethnic communities within the HLF can also affect how information flows through the fishery, which can be both advantageous and unfavorable for individual fishers depending on their position in the overall network structure. Though how this explicitly affects individual fishers remains unclear, it may affect their attitudes and beliefs concerning fishery management or policy, their actions regarding fishing strategies, as well as their economic performance in the fishery. Future work will attempt to determine the extent of these effects in order to shed further light on the impacts of social networks and ethnic diversity among pelagic fishers.

6.2 Bridging Ties and Key Actors

Though our results identified a clear homophily effect among HLF fishers along ethnic lines, we also found that ethnic fisher groups are not completely isolated from one another, and bridging ties do exist across groups. These bridging ties that span ethnic communities may be facilitating access to external resources and diverse knowledge, which may increase the ability of this fishery to effectively respond to impacts such as climate change. Bridging ties such as these

are thought to increase the overall adaptability of natural resource systems because they allow stakeholders a greater variety of resources and ideas when faced with change or external shocks.

Also of interest when considering bridging ties are the actors that these ties connect. These actors are often thought to occupy key positions in the overall network structure and may be able to foster trust across groups and facilitate joint-action. On the other hand, actors occupying these key positions, often referred to as gatekeepers, may potentially impede collaboration if they feel obstructing the transfer of sound information or access to resources across groups benefits their own self-interest (Bodin and Crona 2009). It may also be the case that these actors are simply not interested in fostering trust across groups or acting as a catalyst for joint-action, or are simply unaware of their valuable position. Though the interests and awareness of these gatekeepers are not easily hypothesized, in this case it's probable the competitive nature of fishing may be causing self-interest to be the primary behavior motivator rather than the potential for collaboration and cooperation.

Irrespective of their intentions, key actors forming bridging ties across ethnic communities may be crucial for overcoming the boundaries of ethnic fragmentation, and further analysis into the characterization of these ties may be helpful for fishery managers. For example; who are these key actors, how are these ties formed, and what type of information flows through them? Identifying these actors and bringing them into the decision making process would most likely benefit the long-term sustainability and adaptability of the fishery. These gatekeepers may be more able to influence understanding and cooperation among fishers in regards to policies and regulations, and aid in disseminating technological and scientific information across the diverse communities of the HLF. This type of collaboration would also ensure that fisher's interests are represented in the management arena; which may further influence cooperation and compliance among fishers.

6.3 Ethnic Community Networks

In this analysis of fisher's social network capital, diverse network structures were found among ethnic communities. The E-A community reflects more of a bridging network structure, while the K-A and V-A communities reflect more of a bonding network structure. These findings are consistent with previous sociological research on ethnicity and social networks (Romani 2003), and suggest that though there may be a low ability to enforce social norms across the fishery as a whole, social norms may be more easily enforced within the K-A and V-A communities where higher levels of trust and reciprocity most likely exist. Joint-action and collaboration are also more likely to be achieved within the K-A and V-A communities, whereas fishers in the E-A community may be faced with the same barriers to enforcing social norms and fostering joint action within their community that are likely to be impacting the fishery as a whole. On the other hand, due to the tight bonding structure of the K-A and V-A communities, information and resources circulating within these communities may become redundant; whereas fishers in the E-A community, which is made up of a weaker bridging network structure, may be benefiting from increased access to non-redundant and diverse information, such as information on technological innovations.

6.4 Linking Ties in the V-A and K-A Community

This study provides a unique result concerning linking social capital and minority ethnic groups. Previous theoretical and empirical research has shown that typically the dominant ethnic group (the E-A community in this case) displays a higher level of linking social capital; however,

here we found the V-A community, an ethnic minority, to have the highest level of linking social capital ties. There are various reasons why the V-A community may have reported more links to industry leaders, government or management officials, and the scientific community than the E-A community; one reason may be attributed to the V-A community's involvement with the recently developed organization VAK Fisheries. V-A fishers also represent the majority of fishers currently operating in the fishery, and it's possible that, in this case, system-level dominance may be playing a greater role than local dominance. However, the precise reasons for this unique result can only be revealed with further research.

In any event, the higher level of linking social capital found in the V-A community is likely to be benefiting V-A fishers. Higher levels of linking social capital can increase opportunities for V-A fishers to access information on technological innovations, scientific research, and potential regulatory shifts. It can also provide increased access to resources and help to ensure that V-A fisher's interests are represented in the management and policy arena. A future agenda is to explore how these connections impact the economic performance of individual fishers, where we will pay close attention to the impact of linking social capital ties on individual fisher's economic returns.

In contrast to V-A fishers, the K-A community appears quite marginalized in regards to linking social capital ties, suggesting that K-A fishers may substantially benefit from further outreach.

7. CONCLUDING REMARKS

Though uncertainty persists surrounding the question of how to foster network ties or advantageous network structures for effective resource management, understanding network characteristics and the factors that influence the formation of social networks are a crucial first step to advancing this field. Here we analyzed information sharing and fishers' social network capital at the group level paying particular attention to ethnic diversity. This research fills a critical gap in the social network and natural resource management literature regarding ethnic diversity among stakeholders, while also providing crucial information for fishery managers. It is our hope that these results can not only aid fishers, fishery managers, and other interested parties that aim to foster a sustainable future for Hawaii's longline fishery; but also help to advance the social network and natural resource management literature in hopes of creating a more sustainable future for all natural resource systems.

Our next phase of this research is to delve below the group level analysis and more explicitly investigate individual social network capital. While we found that there are significant differences in social network structure across ethnic fisher groups, our analysis also reveals a substantial level of heterogeneity of social network capital within these groups. Thus within groups, different actors may possess valuable sources of informational flows not available to other actors. A future agenda is to explore how these differences in social network capital impact the economic and social well being of fishers, and its implications for management.

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