APPENDIX 2. COMPARATIVE NETWORK ANALYSIS

<u>Note to Appendix 2: The conclusions of the network analysis can be found under Network Vulnerability on page 98 and under Concluding Network Analysis on page 105.</u>

The widespread redistribution network of the North Aleutian Basin is equivalent to a circumpacific commodity network. From the U.S. northwest of Puget Sound, north to Alaska, and then south to the Philippines, the connections are widespread and detailed. Within the Alaska region, 29 communities are connected in the networks described solely in this study (Table 1; Figure 1). The network data included transactions where people and often families sent goods or subsistence foods from wide-ranging locations, while local goods were sent to distant communities tying together individuals, households, families, friends, and marriages across Alaska and the Pacific.

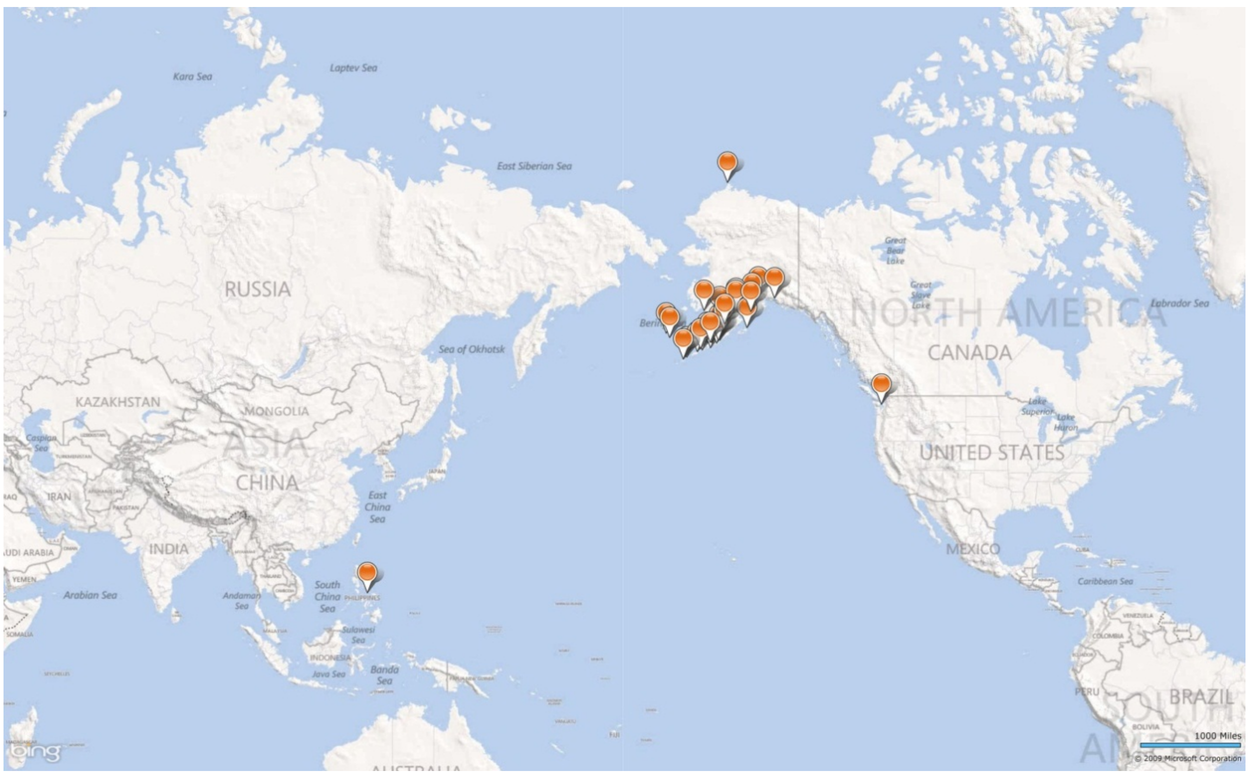

Figure 1. Global map of the distribution networks for four North Aleutian Basin Communities.

Some of the transactions were labeled simply as “outsiders”, or “friends from Barrow”, or “family from Philippines.” We know little about these transactions except the goods. At both the individual level, and the level of households, other important entities entered the transaction networks. The most critical of these are entities, labeled (E), that include both businesses such as canneries (most important), or towns, such as when someone claimed to have given some commodity to “everyone in Akutan.” These will be separated in the network analysis in the future, but here they are combined on the charts, although detailed differentially in the discussion. Other entities are labeled (I) or (P). These are individuals who are either known to the network but were not in one of the surveyed families (P), or are known individuals who are outside the regional genealogy. Some network nodes are listed as (?), these are people or groups in the network for which we have little data. They might include "friends in Chignik", or "cousin in Barrow", or something similar. The colors are random and used to simply for visualization. The size of the nodes is a measure of the number of connections for that node.

In this study we focus on individuals and households. In many cases these overlap closely. But some individual networks get larger and more complex when lumped by household. Networks are organized along both giving and receiving, but may also include purchases when those purchases involve subsistence goods. We also collected data at the family and community level. There are two reasons we do not use these data in this study. First, the family-based data overlap closely, but not exactly so, with the household data. But these differences do not add anything to the overall structure of the household networks. Second, the community-based networks are beyond the scope of this study, and when studied from the community level, and the networks lose much of their resolution.

Previous to Magdanz's work in Seward Peninsula communities, the Subsistence Division documented the occurrence of sharing without much context or detail. Figure 2 shows the number of households engaged in receiving and giving from the baseline studies and the 2009 survey data. Magdanz's use of social networks to analyze mixed economies dramatically changed the way these activities are documented (2011). Economies of rural Alaska are complex and multifaceted and it is easy to lose the richness of the data when trying to demonstrate aspects of the economy. Magdanz acknowledges many limitations of the analysis, data preparation and entry is very time consuming, and data confidentiality is hard to maintain for small villages.

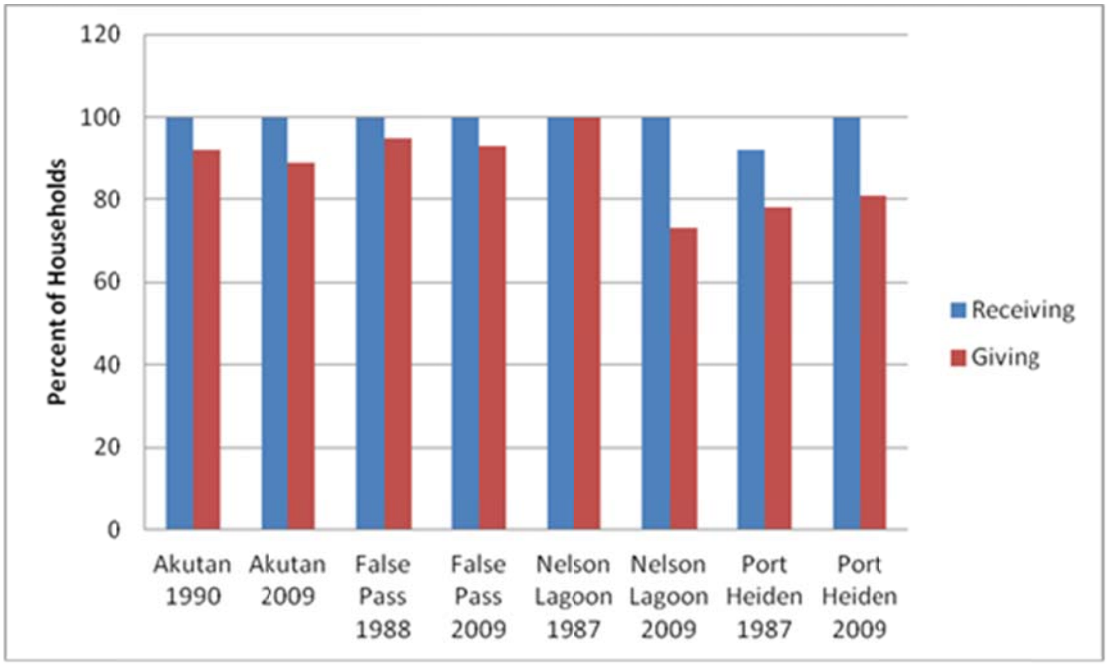

Figure 2. Standard way Subsistence Division has characterized sharing, comparing baseline studies and this study.

Table 1. All communities, regions, and countries mentioned in any transactions from the project.

Community	Transactions	Transactions Out	Transactions In
Akutan	801	788	761
Port Heiden	349	284	339
False Pass	307	265	252
Nelson Lagoon	288	210	260
King Cove	110	82	48
Anchorage	63	17	46
Outsiders	17	14	3
King Salmon	16	16	0
Chignik Lake	13	11	2
Dutch Harbor	12	1	11
Unalaska	12	1	11
Perryville	11	10	1
Dillingham	11	9	2
Sand Point	9	7	2
Barrow	8	5	3
Chignik	6	5	1
Bear Lake	6	6	0
Kodiak	5	5	0
Kenai	4	1	3
Port Moller	3	3	0
Pilot Point	2	2	0
St. Paul	2	0	2
Cold Bay	2	2	0
Quinhagak	2	2	0
Egegik	1	0	1
Port Orchard, WA	1	4	0
Valdez	1	1	0
St George	1	2	2
Philippines	1	0	1
Homer	1	1	0
Iliamna	1	1	0
Nondaltan	1	1	0

Below we demonstrate the power of individual-based networks for analyzing the structure of transactions across the study area. We show that different species and harvests result in highly disparate networks. We further show that specific harvest methods and commercial activities have created co-dependencies that are often outside what are commonly considered traditional subsistence networks. Specifically, the most important transactions for some species are controlled by the distribution of canneries, crab rationalization, marine fish processing, and similar factors. We will show that while salmon networks are largely structured around commercial fishing permits, non-crab shellfish and plants appear to be structured around more traditional distribution networks. Conversely, king crab distribution networks, which are critical to family feasts and events, are solely dictated by access to canneries because local males' roles in the king crab harvest has dramatically declined.

INDIVIDUAL NETWORKS

One of the most important findings of this study is the massive "connectedness" of the regional transaction networks (Figure 3). More than 98 percent of all people mentioned in the surveys are connected, using all species, in a single large network.   Only four small networks are outside the regional pattern. This network alone demonstrates the extent of the regional connections. These data replicate the regional genealogy as created by Reedy-Maschner. But different from the regional genealogy, these networks demonstrate the importance of affinal relations. Because the north Pacific has been traditionally a bi-lateral kinship system, especially since the introduction of Russian Orthodoxy in the 18^{th} century, we will show that there is little specific emphasis on consanguineal kin relations, but a considerable emphasis on kin reckoned through bi-lateral recognition. This is clear where the transactions are just as critical to marriage relations as they are to blood relations.

Table 2 highlights the data from the combined networks. In the largest network alone there are 87 surveyed households representing 103 families in the regional genealogy. There are also 170 nodes who are individuals or other entities not in the surveyed households. Table 3 is a listing of all the taxa identified in any of the transactions, with a total of 59 taxa, some to species, many to genus, family or order. In some cases we used common regional names where the exact classification was unclear. The dominant role of some taxa over most others is clear from these data.

Table 4 provides correlation coefficients for the data presented in Table 2. Overall, we will show throughout this study that all of the categories of classification in these datasets are highly correlated. In nearly all cases, the size of the network in terms of transactions and nodes is directly correlated with the numbers of households and families participating in the transactions for that network. The numbers of communities are generally not well correlated with the rest of the data, at least less so, except for specific cases.

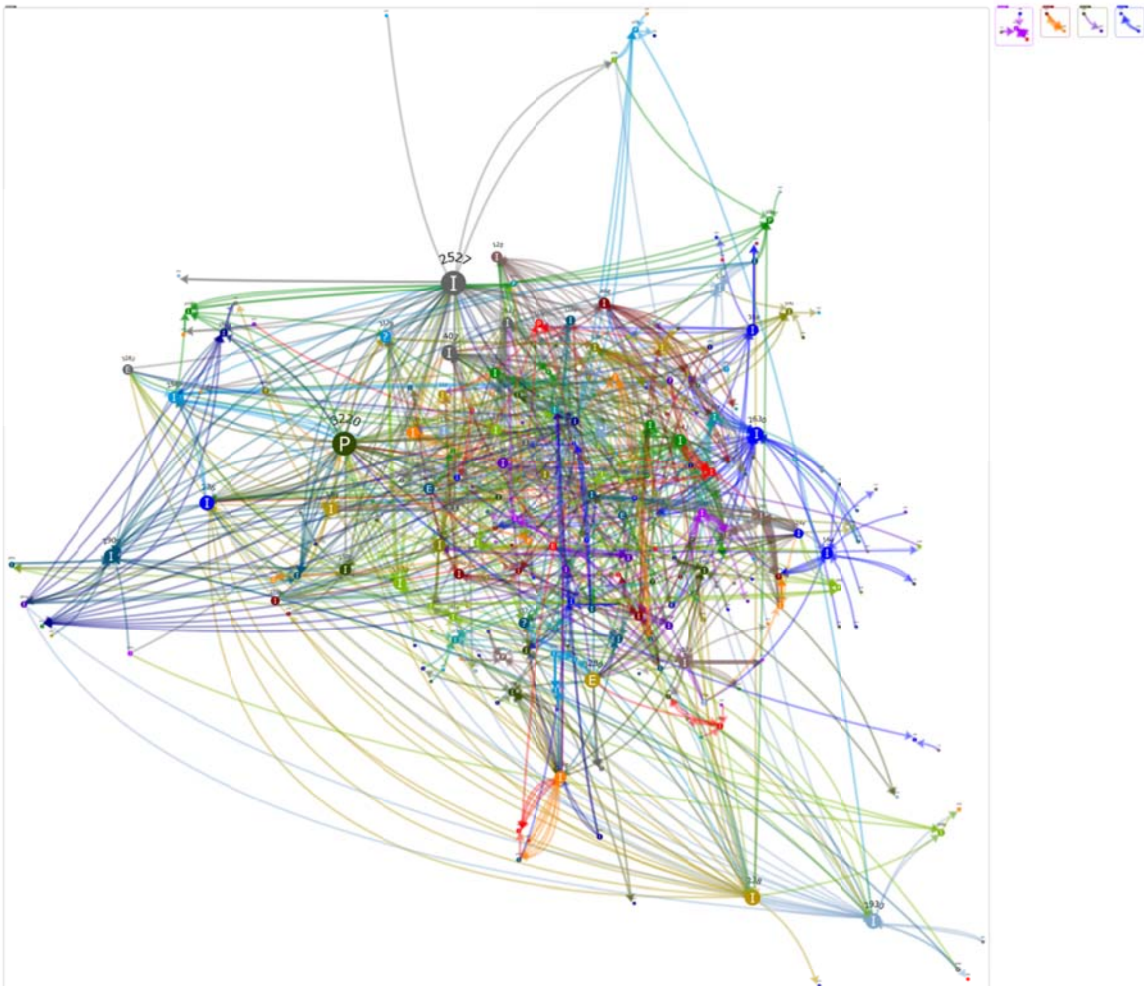

Figure 3. The combined network of all people either surveyed or named by an informant in the survey. Using all species and all transactions, nearly everyone is connected in a large network. Four small networks that have no connection with the larger network are attached at right. Node size is a relative measure of the number of connections.

Table 2. Over 96% of the nodes, 98% of the transactions, and over 92% of the surveyed families and households are connected into a single massive network of giving and receiving.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	267	1003	30	103	37	67	26	87	73	42	62
2	4	12	2	4	0	0	0	1	3	0	0
3	2	5	1	1	0	1	0	1	0	1	0
4	2	1	2	0	1	1	0	1	0	1	0
5	2	2	1	0	1	1	1	1	0	0	1

Table 3. All taxa by rank order of number of transactions.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Oncorhynchus nerka	118	118	14	62	16	11	6	70	21	11	6
Hippoglossus stenolepsis	103	92	13	52	13	11	7	60	16	11	7
Gadus macrocephalus	71	56	9	41	4	9	4	48	8	9	4
Octopus dofleini	70	56	11	38	5	12	3	44	9	12	3
Paralithodes sp. and Lithodes sp.	66	56	8	41	7	4	5	53	2	4	5
Larus sp.	59	41	8	37	4	6	0	39	10	6	0
Bos sp.	34	39	3	19	5	3	1	28	2	3	1
Alces alces	39	33	9	26	4	5	2	27	3	5	2
Empetrum nigrum	43	30	10	24	4	4	3	29	3	4	3
Oncorhynchus tshawytscha	42	30	7	28	6	4	2	26	9	4	2
Lagopus sp.	50	28	10	37	6	2	2	30	12	2	2
Rangifer tarandus	38	28	8	25	0	5	2	21	7	5	2
Katharina tunicata	38	25	8	25	3	2	2	21	9	2	2
Oncorhynchus kisutch	37	24	6	24	7	4	0	22	9	4	0
Eumetopias jubatus	26	24	1	17	1	2	1	20	1	2	1
Rubus chamaemorus	36	23	9	21	6	2	4	20	8	2	4
Phoca vitulina	33	23	6	19	2	5	3	19	4	5	3
Oncorhynchus gorbuscha	30	19	4	16	5	5	2	18	5	5	2
Salvelinus malma	29	19	5	18	7	2	0	17	7	2	0
Anatidae family	28	17	8	22	1	3	1	18	6	3	1
Chionoecetes bairdi and C. opilio	24	14	7	16	1	3	4	15	2	3	4
Oncorhynchus sp.	19	12	5	14	1	2	0	13	1	2	0
Oncorhynchus keta	18	12	6	9	1	4	1	12	1	4	1

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Branta bernicla	16	12	5	10	4	1	0	10	3	1	0
class Bivalia	17	10	7	13	0	2	0	9	5	2	0
Chen canagica	17	9	6	15	1	1	1	11	3	1	1
Vaccinium uliginosum	16	9	4	8	6	0	1	8	6	0	1
Rock Duck	13	9	2	9	2	1	0	8	3	1	0
Saxidomus giganteus	12	8	3	12	1	0	0	4	8	0	0
Branta canadensis	13	7	5	9	1	3	0	10	0	3	0
Strongylocentrotus droebachiensis	11	7	3	9	0	1	0	7	3	1	0
Fratercula sp.	10	7	1	7	0	0	0	7	3	0	0
Epilobium angustifolium	8	7	2	4	1	0	0	5	2	0	0
Thaleichthys pacificus	10	6	4	5	2	1	1	6	2	1	1
family Phocidae	10	6	1	8	0	1	0	9	0	1	0
Callorhinus ursinus	8	6	2	6	0	2	0	5	1	2	0
suborder Pinniped	10	5	3	8	1	0	0	8	2	0	0
Ligusticum scoticum	9	5	3	6	0	0	1	7	1	0	1
Berries-unknown	9	5	3	8	0	0	0	8	1	0	0
Anas crecca	8	5	2	6	2	0	0	5	3	0	0
Sebastes sp.	8	4	3	4	0	3	1	4	0	3	1
Polygonum alpinum	8	4	2	6	0	2	0	6	0	2	0
Frageria chiloensis	8	4	3	8	0	1	0	7	0	1	0
Clincardium sp.	8	4	3	5	1	1	1	6	0	1	1
Vaccinium ovalifolium	7	4	2	6	1	0	0	5	2	0	0
Siliqua sp.	7	4	5	4	0	1	2	4	0	1	2
Melanitta sp.	7	4	2	6	1	0	0	4	2	0	0
Histrionicus histrionicus	7	4	1	5	1	0	0	4	3	0	0
Ophiodon elongatus	5	4	2	2	0	0	1	4	0	0	1
Cancer magister	6	3	5	3	0	1	1	3	1	1	1
Huckleberries	5	3	2	3	1	0	1	2	2	0	1
Wineberries	4	2	2	3	1	0	1	3	0	0	1
Vaccinium vitis-idaea	4	2	3	3	1	0	0	3	1	0	0
Unknown Trout	4	2	1	3	0	1	0	3	0	1	0
Unknown Goose	4	2	1	3	0	1	0	3	0	1	0
order Large Cetacea	4	2	4	2	0	1	1	2	0	1	1
Oncorhynchus mykiss	4	2	3	2	0	1	1	2	0	1	1
Heracleum lanatum	4	2	3	3	0	0	1	2	1	0	1
Anas platyrhynchos	4	2	3	4	0	0	0	2	2	0	0
Balaena mysticetus	3	2	2	1	1	0	1	2	0	0	1

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Tundra Tea	2	1	1	2	0	0	0	2	0	0	0
Sterna sp.	2	1	1	2	0	0	0	2	0	0	0
Sebastes melanops	2	1	1	2	0	0	0	2	0	0	0
Sea eggs	2	1	1	1	0	0	0	1	1	0	0
Salvelinus namaycush	2	1	1	2	0	0	0	2	0	0	0
Salmonidae family	2	1	2	1	0	0	1	1	0	0	1
Odobenus rosmarus divergens	2	1	2	1	1	0	0	1	1	0	0
Mushrooms	2	1	1	0	1	1	0	1	0	1	0
Lepus othus	2	1	2	1	0	1	0	1	0	1	0
Honchenya peploides	2	1	2	1	1	0	0	1	1	0	0
Grus canadensis	2	1	1	1	0	1	0	1	0	1	0
Erethizon dorsatum	2	1	1	1	0	1	0	1	0	1	0
Enhydra lutris	2	1	1	2	0	0	0	1	1	0	0
Coregonus sp.	2	1	2	1	0	1	0	1	0	1	0
Clupea pallasii	2	1	1	1	0	1	0	1	0	1	0
Bucephala clangula	2	1	1	2	0	0	0	1	1	0	0
Brook Trout	2	1	2	2	0	0	0	1	1	0	0
Bison bison	2	1	2	1	0	1	0	1	0	1	0
Baffleheads (Darryl Pelkey)	2	1	1	1	1	0	0	2	0	0	0
Aythya afinis	2	1	1	2	0	0	0	2	0	0	0
Athyrium felix-famine	2	1	2	1	1	0	0	1	1	0	0

Table 4. Correlation coefficients for the species data presented in Table 2.

	Nodes	*Transactions*	*Communities*	*Families*	*Non-Family nodes (P, I)*	*Non-Family nodes (?, O)*	*Non-Family nodes (E)*	*Households*	*Non- Household nodes (P, I)*	*Non- Household nodes (?, O)*	*Non- Household nodes (E)*
Nodes	1.000										
Transactions	0.983	1.000									
Communities	0.889	0.829	1.000								
Families	0.986	0.951	0.898	1.000							
Non-Family nodes (P, I)	0.877	0.882	0.746	0.841	1.000						
Non-Family nodes (?, O)	0.904	0.889	0.819	0.867	0.713	1.000					
Non-Family nodes (E)	0.827	0.821	0.800	0.784	0.720	0.749	1.000				
Households	0.989	0.974	0.862	0.981	0.851	0.889	0.813	1.000			
Non- Household nodes (P, I)	0.870	0.836	0.803	0.873	0.849	0.718	0.633	0.806	1.000		
Non- Household nodes (?, O)	0.904	0.889	0.819	0.867	0.713	1.000	0.749	0.889	0.718	1.000	
Non- Household nodes (E)	0.827	0.821	0.800	0.784	0.720	0.749	1.000	0.813	0.633	0.749	1.000

Figure 4 is a rank order bar chart for all of the data presented in Table 3. Here the top seven taxa, which in order are sockeye, halibut, cod, octopus, king crab, gull eggs, and cattle, are clearly dominant in these data. The top seven taxa, plotted as a network in Figure 5, show a single primary network, and the majority of surveyed individuals and households are represented in this network. In this network structure a number of smaller networks are included that appear loosely connected. On the left side of Figure 5, there is a *star* pattern network where a few key nodes are connected to a large number of individual nodes: these are sometimes referred to as *centralized* networks. The network on the right is a *cluster* pattern network, with many cross-connections throughout its structure: these are sometimes referred to as *decentralized* networks. Both of these network styles are important to the following discussion of all individual networks and the individual taxa. The fundamental differences between the two is that the star patterns are highly vulnerable to the loss of a single provider, while the cluster patterns, because of their greater interconnectedness, are much more stable and resilient.

Table 5 shows the dominance of the connections seen in the largest network. The four smaller networks have only limited interconnectedness. It is remarkable that with simply seven taxa the massive network can be replicated as presented in Figure 3. But these data are also somewhat concerning because this also shows how specialized the subsistence economy has become. While the networks in this study are focused primarily on the role of individuals and households in measuring their resilience and sustainability, the data presented in regards to these top seven taxa also indicate the vulnerability of the entire structure. The loss of single taxa, such as sockeye, or octopus, or king crab, creates a highly diluted series of networks with considerably less strength. The important point is that because the regional exchange networks appear rather specialized on the few species, the region has lost much of its resilience because there are so few alternative taxa actively exchanged in the network system.

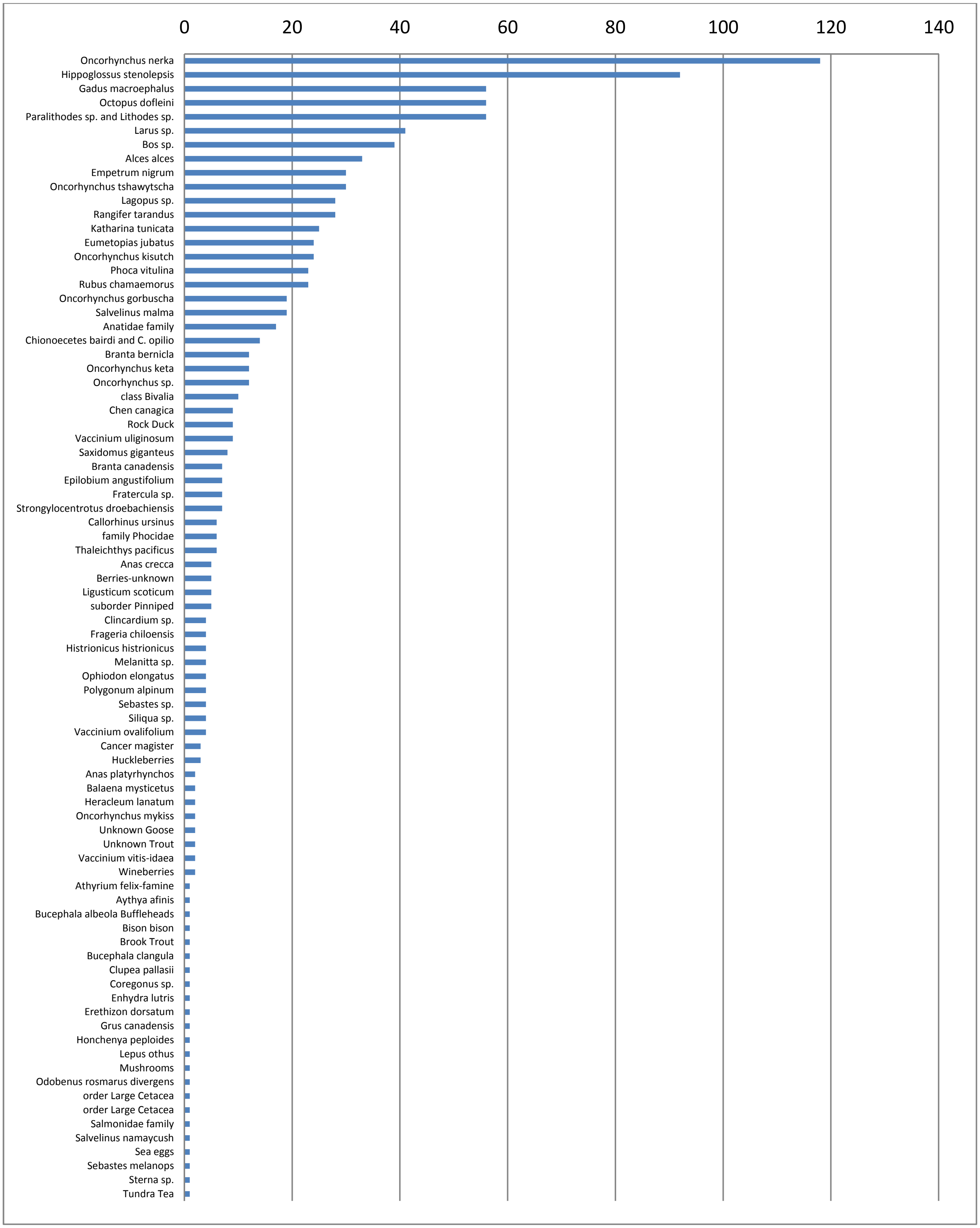

Figure 4. Rank order of the most important taxa based on numbers of overall transactions. Here we find that red salmon, halibut, cod, octopus, king crab, gull eggs, and wild cattle are the top seven commodities exchanged in the region.

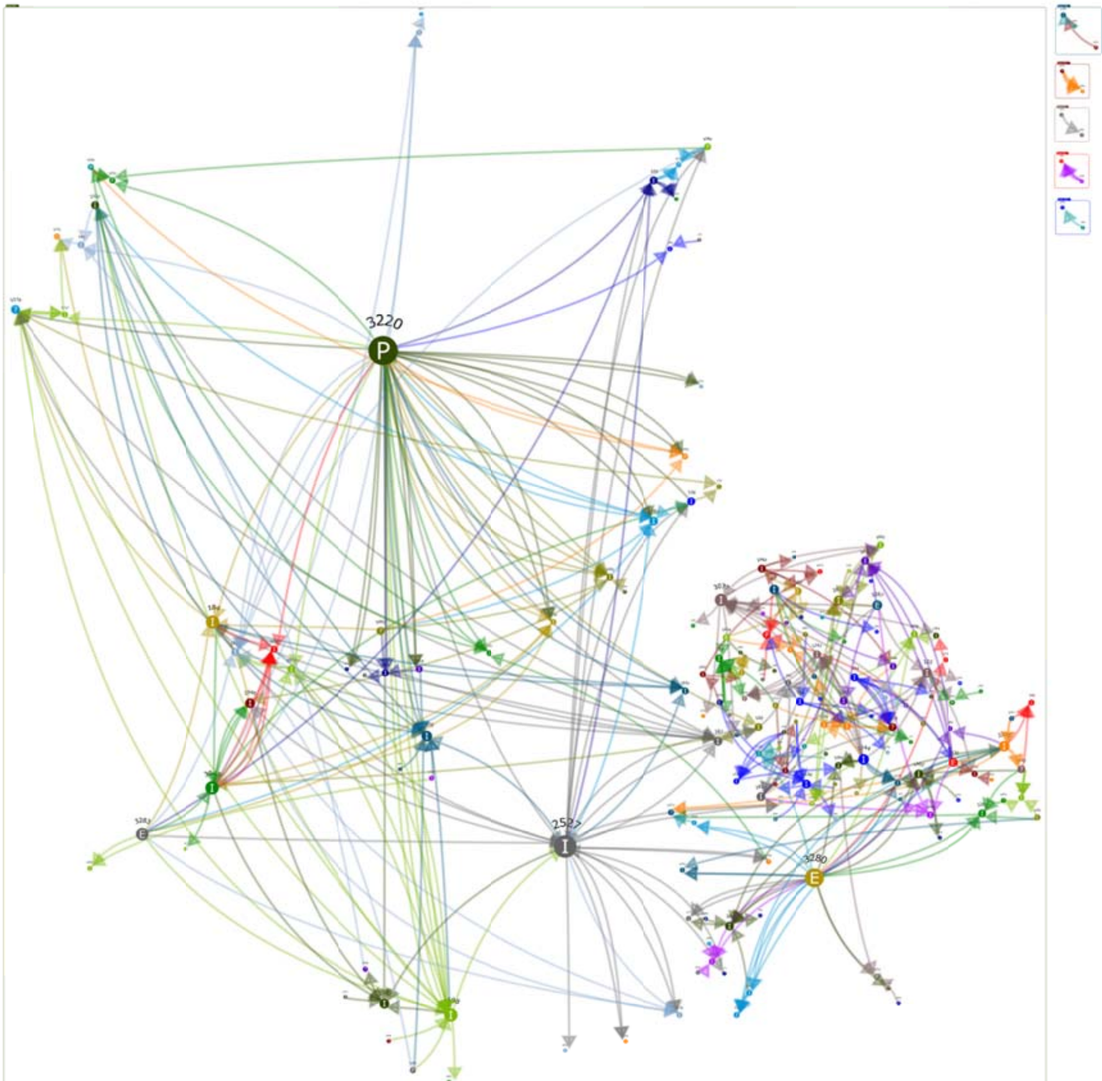

Figure 5. Combined transaction network of the top seven taxa from Figure 4. On the top left and the bottom center are two star pattern networks where a single large node is connected to many single nodes. On the right is a cluster pattern network.

Table 5. Network data for Figure 4, based on the top seven taxa in the network transactions. The majority of surveyed families and households are participating in sharing one or more of the top seven taxa.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	267	1003	30	103	37	67	26	87	73	42	62
2	4	12	2	4	0	0	0	1	3	0	0
3	2	5	1	1	0	1	0	1	0	1	0
4	2	1	2	0	1	1	0	1	0	1	0
5	2	2	1	0	1	1	1	1	0	0	1

Salmon networks are critically important in the project area. Nearly everyone in these networks is centered around a commercial permit holder. In Figure 6 we present the networks for all salmon combined. There are four large networks, four intermediate networks, and a group of smaller networks. In all cases there is considerable interconnectness indicating that these networks may have some resilience against the loss of the single provider. Table 6 is a breakdown of the five species of salmon based on their importance in the system. We see from these data that sockeye are the most important taxa. In Figure 7 we present the networks based solely on sockeye salmon. The reason the sockeye networks are so similar in size and structure to the combined salmon networks seen in Figure 6 is simply a measure of the critical role sockeye salmon plays in the economy of this region. While other species of salmon are certainly exchanged, sockeye is dominant. In Table 7 and 8, the complete network data for both the combined salmon networks in Figure 6 is presented, and the sockeye networks in Figure 7. In the combined data there are 17 networks and in the sockeye data there are 20 networks for sockeye alone, indicating that other salmon species provide the connections in the larger network structure.

Freshwater fish play only a small role in the regional networks (Figure 8). Dolly Varden (*Salvelinus malma)* are the most important species based on all categories of data (Table 9). Lake trout stand out in these data only because of the high number of non-household and non-family transactions which are a product of transactions involving sport fishermen. Table 10 shows the small size of the freshwater fish networks.

Marine fish networks are large and integrated. Figure 9 shows three major marine fish networks, each dominated by 1-3 key nodes. These three networks combine to include nearly all those individuals and transactions involved in marine fish exchange (Table 11). As can be seen in Table 12, more than 90 percent of the marine fish transactions are cod and halibut. These are the two most important marine fish in all categories of the data. The first two networks on Figure 180 are cod and halibut combined, the third largest in primarily cod. What makes this third network interesting is that the primary source node is labeled “E”. This is an entity designation for a cannery. This entire network revolves around individuals who purchase their cod form a processor.

Broken down by the dominant species, the halibut networks are typical of a spoke pattern where a few key providers supply most of the product (Figure 10). Table 13 is a complete breakdown of the halibut network data showing the importance of the largest network. The cod networks in Figure 11 and as described in Table 14, show similar patterns to the halibut networks except for two details. First, there are four major networks of fairly even size, each ranging from 6-12 transactions around 7-13 nodes. The second difference is the largest network, which is completely structured around a cannery where cod purchases provide the critical access to this key species.

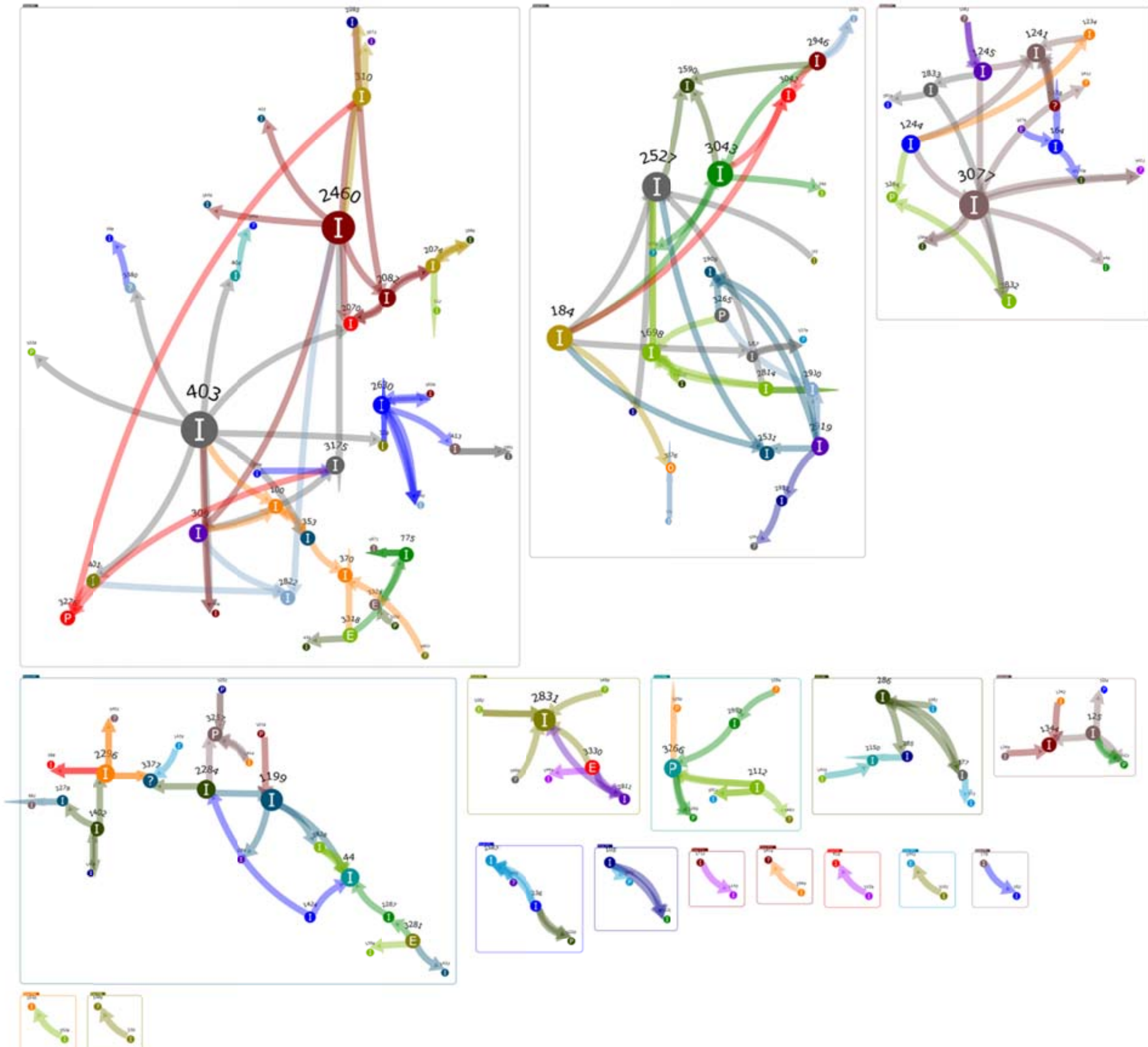

Figure 6. Salmon networks in the region. These networks are dominated by sockeye salmon, the majority of which are taken from commercial nets. Non-commercial subsistence harvests of pink and coho salmon make up the smaller networks.

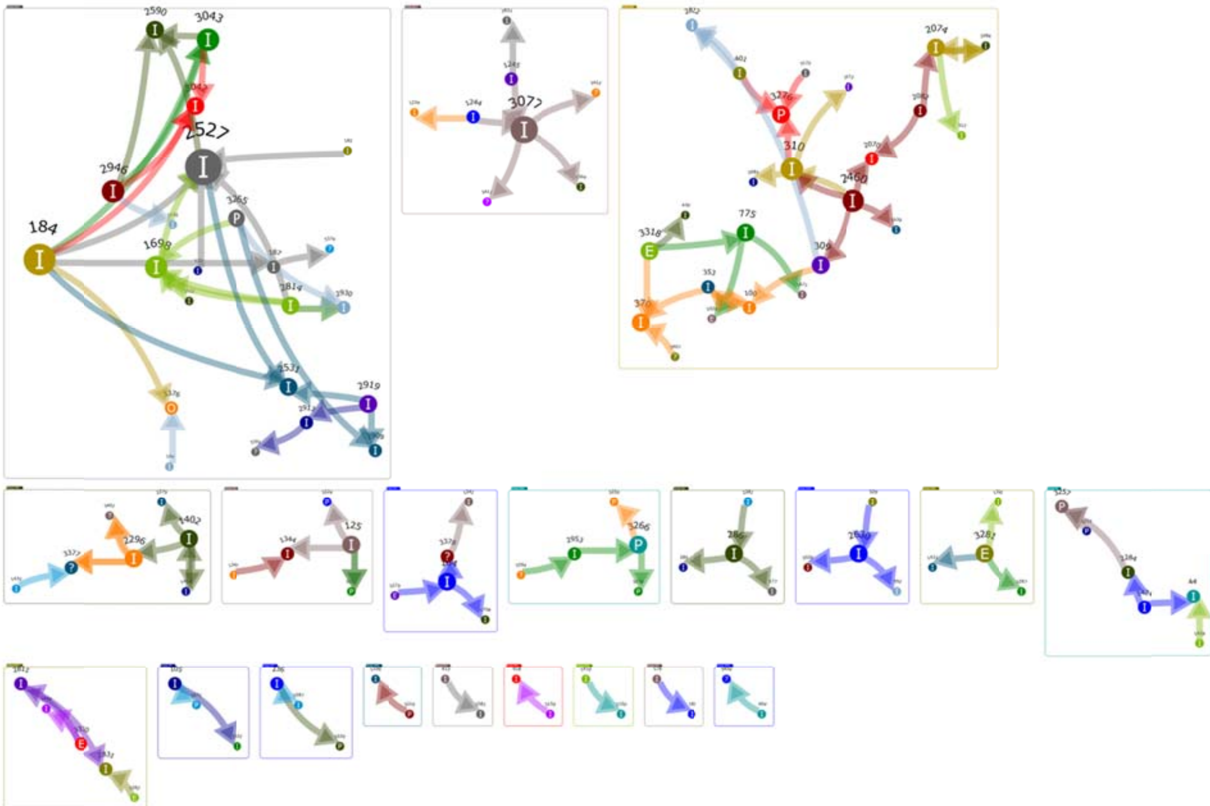

Figure 7. Sockeye salmon networks are mostly village-based and attached to commercial harvesters.

Table 6. . Salmon transactions based on the networks in Figure 6.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Oncorhynchus keta	18	12	6	9	1	4	1	12	1	4	1
Oncorhynchus nerka	118	118	14	62	16	11	6	70	21	11	6
Oncorhynchus tshawytscha	42	30	7	28	6	4	2	26	9	4	2
Oncorhynchus kisutch	37	24	6	24	7	4	0	22	9	4	0
Oncorhynchus sp.	19	12	5	14	1	2	0	13	1	2	0
Oncorhynchus gorbuscha	30	19	4	16	5	5	2	18	5	5	2

Table 7. All salmon networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	40	62	6	19	6	3	2	21	10	3	2
2	25	45	1	14	2	4	0	16	4	4	0
3	18	27	6	10	1	4	1	8	3	4	1
4	23	32	4	12	3	2	1	18	1	2	1
5	7	9	1	3	0	2	2	3	0	2	2
6	8	10	2	3	3	2	0	4	2	2	0
7	7	7	1	7	0	0	0	6	0	0	0
8	6	7	3	2	2	0	0	3	3	0	0
9	4	6	1	2	1	1	0	2	1	1	0
10	3	3	2	2	1	0	0	2	1	0	0
11	2	1	1	0	1	0	1	1	0	0	1
12	2	1	2	1	0	0	0	1	1	0	0
13	2	1	2	1	0	1	0	1	0	1	0
14	2	1	1	2	1	0	0	1	1	0	0
15	2	1	1	1	0	1	0	1	0	1	0
16	2	1	2	2	0	0	0	1	1	0	0
17	2	1	1	1	0	0	0	1	1	0	0

Table 8. Sockeye networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	23	33	1	13	2	3	0	16	4	3	0
2	24	28	4	14	3	1	2	13	4	1	2
3	8	7	4	5	0	2	0	5	1	2	0
4	7	9	2	3	0	2	0	5	0	2	0
5	5	5	3	2	2	0	0	3	2	0	0
6	5	4	2	4	0	1	1	2	1	1	1
7	5	4	1	1	3	1	0	3	1	1	0
8	4	3	1	4	0	0	0	4	0	0	0
9	4	3	2	3	1	0	0	1	3	0	0
10	4	3	2	3	0	0	1	3	0	0	1
11	6	5	2	4	2	0	0	6	0	0	0
12	5	4	1	3	0	0	2	3	0	0	2
13	3	2	2	2	1	0	0	2	1	0	0
14	3	2	1	2	1	0	0	2	1	0	0
15	2	1	1	1	1	0	0	2	0	0	0
16	2	1	1	2	0	0	0	1	1	0	0
17	2	1	2	2	0	0	0	1	1	0	0
18	2	1	1	2	0	0	0	2	0	0	0
19	2	1	1	1	0	0	0	1	1	0	0
20	2	1	1	1	0	1	0	1	0	1	0

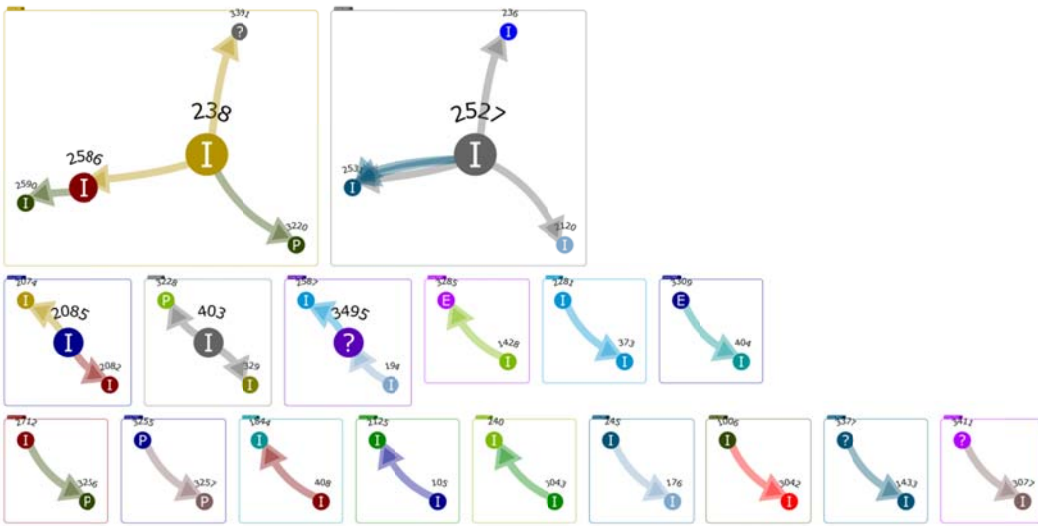

Figure 8. Freshwater fish play a very small role in the exchange transactions of the region.

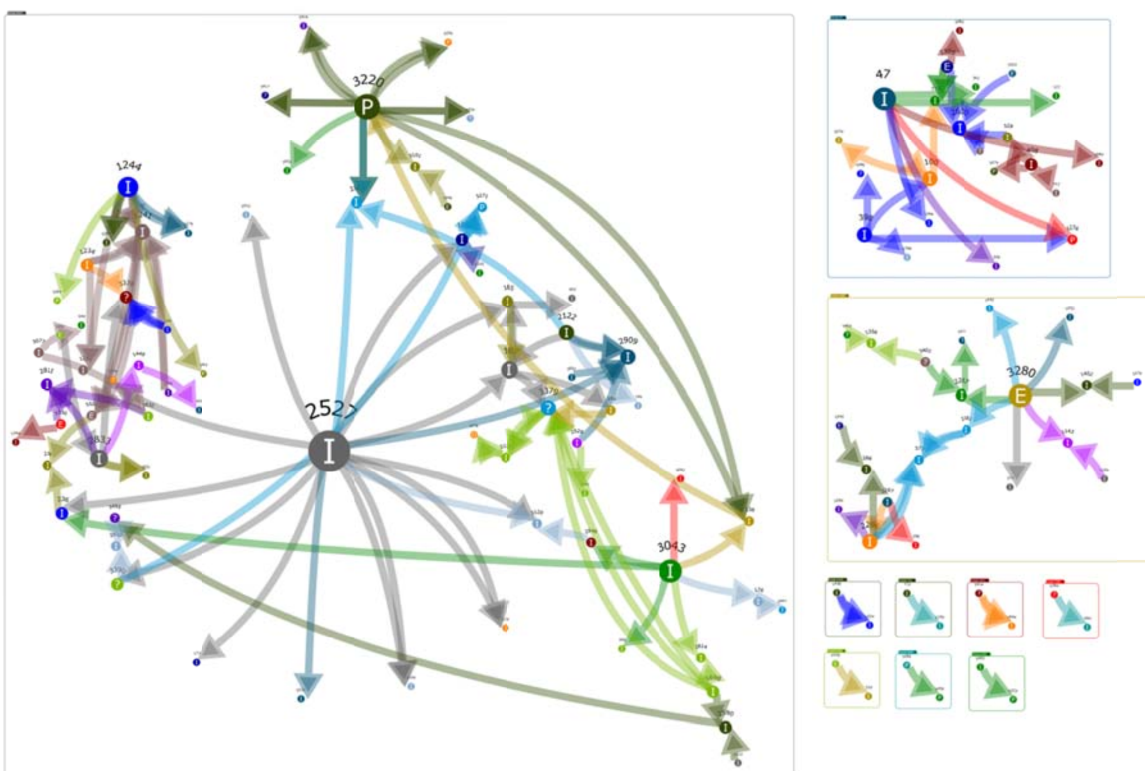

Figure 9. Marine fish transactions result in three regionally-based, well-resolved networks.

Table 9. The only freshwater fish that plays an important role in exchange networks is Salvelinus malma, the Dolly Varden.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Salvelinus malma	29	19	5	18	0	2	0	17	0	2	0
Unknown Trout	4	2	1	3	0	1	0	3	0	1	0
Salvelinus namaycush	2	1	1	2	7	0	0	2	7	0	0
Oncorhynchus mykiss	4	2	3	2	0	1	1	2	0	1	1
Salmonidae family	2	1	2	1	0	0	1	1	0	0	1
Brook Trout	2	1	2	2	0	0	0	1	1	0	0
Coregonus sp.	2	1	2	1	0	1	0	1	0	1	0

Table 10. Freshwater fish networks are small and very local.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	5	4	1	3	1	1	0	4	0	1	0
2	4	5	1	4	0	0	0	3	1	0	0
3	3	2	1	3	0	0	0	2	1	0	0
4	3	2	1	2	1	0	0	1	2	0	0
5	3	2	1	2	0	1	0	2	0	1	0
6	2	1	2	1	0	0	1	1	0	0	1
7	2	1	1	0	2	0	0	1	1	0	0
8	2	1	1	0	2	0	0	2	0	0	0
9	2	1	2	1	1	0	0	1	1	0	0
10	2	1	2	2	0	0	0	1	1	0	0
11	2	1	1	2	0	0	0	2	0	0	0
12	2	1	1	2	0	0	0	2	0	0	0
13	2	1	1	2	0	0	0	2	0	0	0
14	2	1	2	1	0	0	1	1	0	0	1
15	2	1	2	1	0	1	0	1	0	1	0
16	2	1	1	1	0	1	0	1	0	1	0
17	2	1	2	2	0	0	0	1	1	0	0

Table 11. Marine fish networks, one massive network and two medium sized networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	72	110	8	36	7	8	4	41	10	8	4
2	22	23	4	13	4	2	2	13	3	2	2
3	21	22	4	12	0	3	2	12	3	3	2
4	2	2	2	1	0	0	0	1	1	0	0
5	2	1	2	1	0	0	1	1	0	0	1
6	2	1	1	0	2	0	0	1	1	0	0
7	2	1	1	1	1	0	0	1	1	0	0
8	2	2	1	1	0	1	0	1	0	1	0
9	2	1	1	2	0	0	0	1	1	0	0
10	2	1	2	1	0	1	0	1	0	1	0

Table 12. Marine fish networks are dominated by halibut and Pacific cod.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Gadus macroephalus	71	56	9	41	4	9	4	48	8	9	4
Hippoglossus stenolepsis	103	92	13	52	13	11	7	60	16	11	7
Thaleichthys pacificus	10	6	4	5	2	1	1	6	2	1	1
Sebastes sp.	2	1	1	1	0	1	0	1	0	1	0
Ophiodon elongatus	5	4	2	2	0	0	1	4	0	0	1
Sebastes sp.	6	3	2	3	0	2	1	3	0	2	1
Sebastes melanops	2	1	1	2	0	0	0	2	0	0	0
Clupea pallasii	2	1	1	1	0	1	0	1	0	1	0

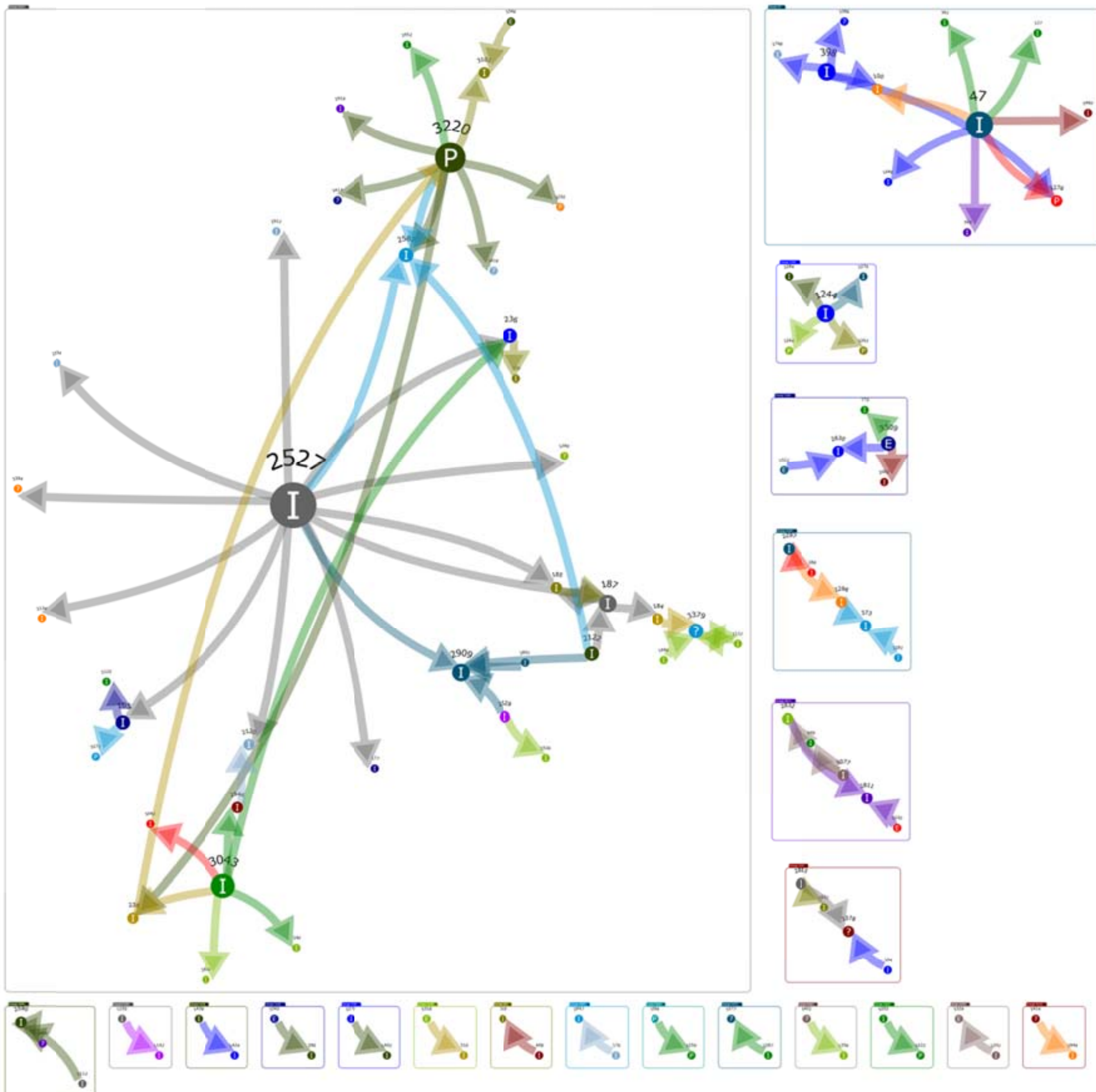

Figure 10. Halibut networks are formed around a few dominant fishermen, and tend to be community based. The largest two networks are in Akutan, and the next five are based in False Pass or Nelson Lagoon.

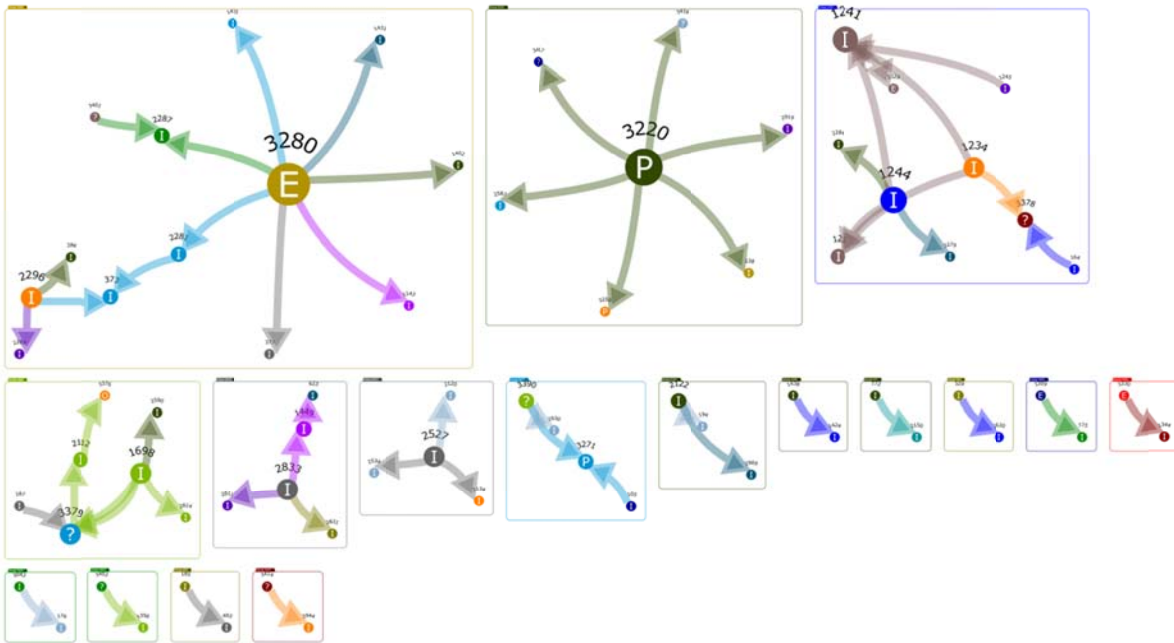

Figure 11. Cod networks are also dominated by important fishermen, except the largest, which is centered around Peter Pan Seafoods and represents fish purchased at the cannery.

Table 13. Halibut networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	39	47	3	20	5	5	1	23	8	5	1
2	11	11	2	6	3	1	0	8	0	1	0
3	5	4	2	2	2	0	0	4	0	0	0
4	5	4	3	3	0	0	2	3	0	0	2
5	5	4	2	4	0	0	0	4	1	0	0
6	5	4	1	3	0	0	1	4	0	0	1
7	4	3	1	2	0	1	0	3	0	1	0
8	3	2	1	2	0	1	0	1	1	1	0
9	2	1	1	2	0	0	0	1	1	0	0
10	2	1	2	1	0	0	0	1	1	0	0
11	2	1	2	1	0	0	1	1	0	0	1
12	2	1	2	2	0	0	0	1	1	0	0
13	2	1	2	1	0	0	1	1	0	0	1
14	2	1	1	2	0	0	0	1	1	0	0
15	2	1	1	2	0	0	0	2	0	0	0
16	2	1	1	0	2	0	0	1	1	0	0
17	2	1	1	1	0	1	0	1	0	1	0
18	2	1	2	1	0	1	0	1	0	1	0
19	2	1	1	1	1	0	0	1	1	0	0
20	2	1	2	1	0	0	1	1	0	0	1
21	2	1	1	1	0	1	0	1	0	1	0

Table 14. Cod networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	13	12	2	10	0	1	1	10	0	1	1
2	7	6	1	3	2	2	0	4	1	2	0
3	10	10	4	5	0	1	1	7	0	1	1
4	7	7	1	5	0	2	0	5	0	2	0
5	5	4	1	4	0	0	0	4	1	0	0
6	4	3	2	2	0	0	0	2	2	0	0
7	4	3	1	2	1	1	0	3	0	1	0
8	3	2	1	2	1	0	0	2	1	0	0
9	2	1	2	1	0	0	0	1	1	0	0
10	2	1	1	2	0	0	0	1	1	0	0
11	2	1	1	2	0	0	0	1	1	0	0
12	2	1	2	1	0	0	1	1	0	0	1
13	2	1	1	1	0	0	1	1	0	0	1
14	2	1	1	2	0	0	0	2	0	0	0
15	2	1	2	1	0	1	0	1	0	1	0
16	2	1	2	2	0	0	0	2	0	0	0
17	2	1	1	1	0	1	0	1	0	1	0

Shellfish networks include all clams, octopus, crabs, and other species of marine invertebrates. The two largest networks show both network types with each pconnected network structure (Figure 12). In Table 15 the three primary species are octopus, king crab, and black katy chitons that are all interconnected in two large and dispersed networks (Table 16).

When these three species are separated into individual networks we see very different patterns (Figures 13-15, Tables 17-19). The black katy chiton networks are small and local. There is little size differential between these networks. These are harvested locally in False Pass and Akutan and brought in by fishermen returning to the community.

The octopus networks show considerable exchange and redistribution linkages with multiple down-link transactions. These networks can be local, or as in the case of the second network, encompass six communities. This is a local and regional delicacy and there are several key providers and central nodes in these networks.

Perhaps the most interesting networks is the shellfish category, and perhaps the most telling in the entire study, are the king crab networks. Because of crab rationalization, young men from these communities are rarely hired to work on crab boats, which means they no longer bring crab home for family feasts, funerals, Christmas, or other key events. Thus, the two largest networks are focused around the two largest canneries as the sole source of crab in these villages. The third largest network has Costco in Anchorage as the central node, a key source of Aleutian king crab in Aleutian villages that have been cut out of the crab access networks.

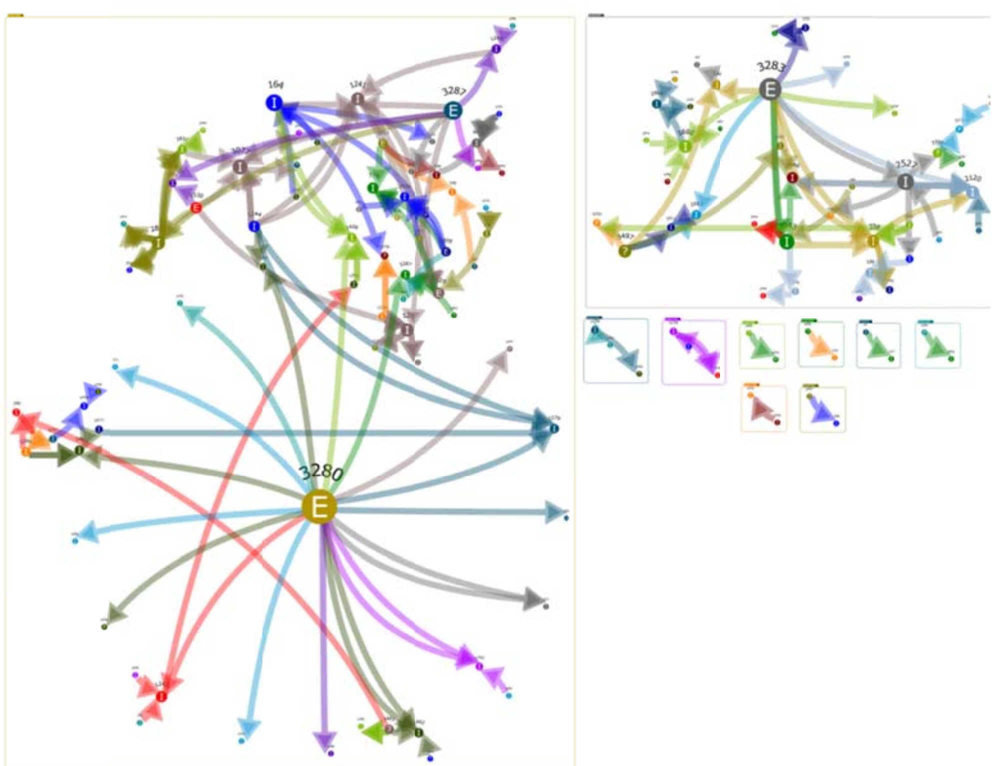

Figure 12. Shellfish networks are an important part of the regionally exchange system. The "E" at the center of some of the largest networks indicates the role of canneries and commercial entities in the distribution of shellfish in the region.

Table 15. The three dominant shellfish taxa in the transaction data are black katy chitons, king crab, and octopus.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Octopus dofleini	70	56	11	38	7	12	3	44	2	12	3
Paralithodes sp. and Lithodes sp.	66	56	8	41	1	4	5	53	2	4	5
Katharina tunicata	38	25	8	25	5	2	2	21	9	2	2
Chionoecetes bairdi and C. opilio	24	14	7	16	0	3	4	15	5	3	4
class Bivalia	17	10	7	13	3	2	0	9	9	2	0
Saxidomus giganteus	12	8	3	12	1	0	0	4	0	0	0
Strongylocentrotus droebachiensis	11	7	3	9	0	1	0	7	1	1	0
Clincardium sp.	8	4	3	5	1	1	1	6	8	1	1
Siliqua sp.	7	4	5	4	0	1	2	4	3	1	2
Cancer magister	6	3	5	3	0	1	1	3	1	1	1
Sea eggs (Urchin)	2	1	1	1	0	0	0	1	0	0	0

Table 16. Two dominant shellfish networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	76	121	11	40	5	8	8	39	15	8	8
2	40	56	4	20	6	7	1	24	5	7	1
3	3	2	2	3	0	1	0	2	0	1	0
4	3	3	2	3	0	0	0	1	2	0	0
5	2	1	1	1	1	0	0	2	0	0	0
6	2	1	1	1	1	0	0	1	1	0	0
7	2	1	1	0	1	1	0	1	0	1	0
8	2	1	2	1	0	1	0	1	0	1	0
9	2	1	2	1	0	0	0	1	1	0	0
10	2	1	2	1	0	1	0	1	0	1	0

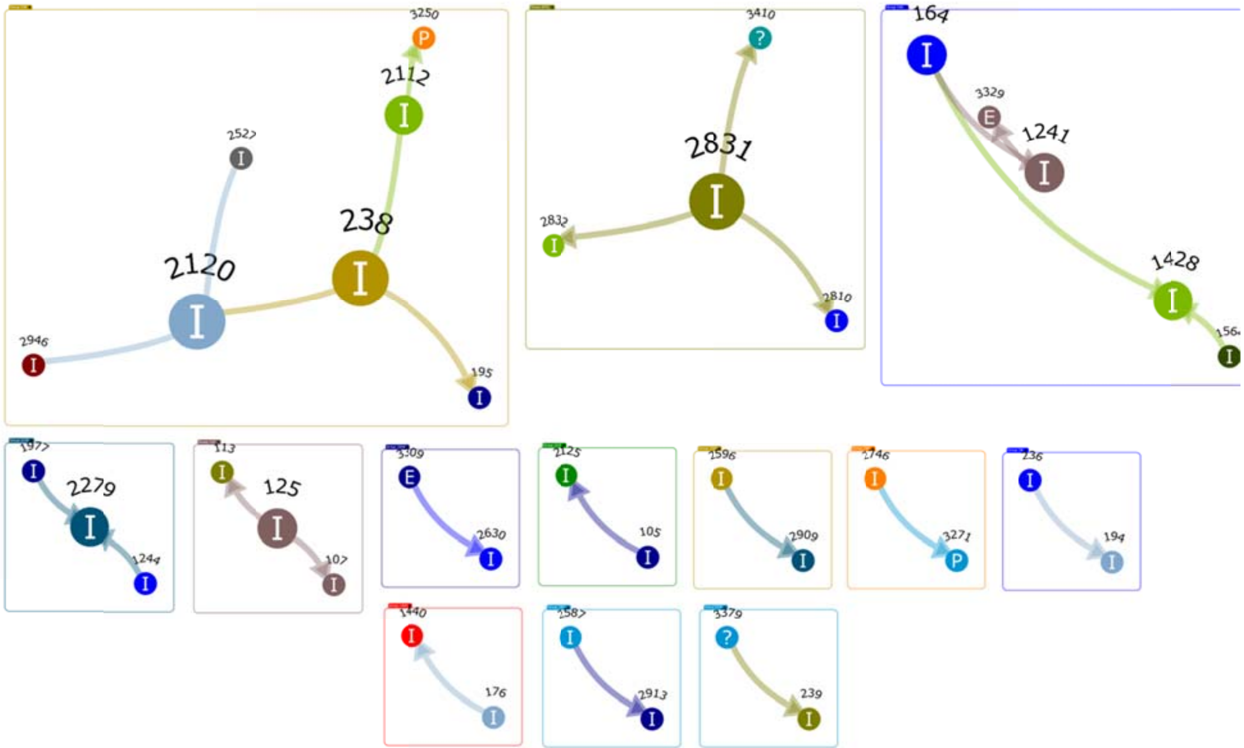

Figure 13. Black katy chiton exchange networks.

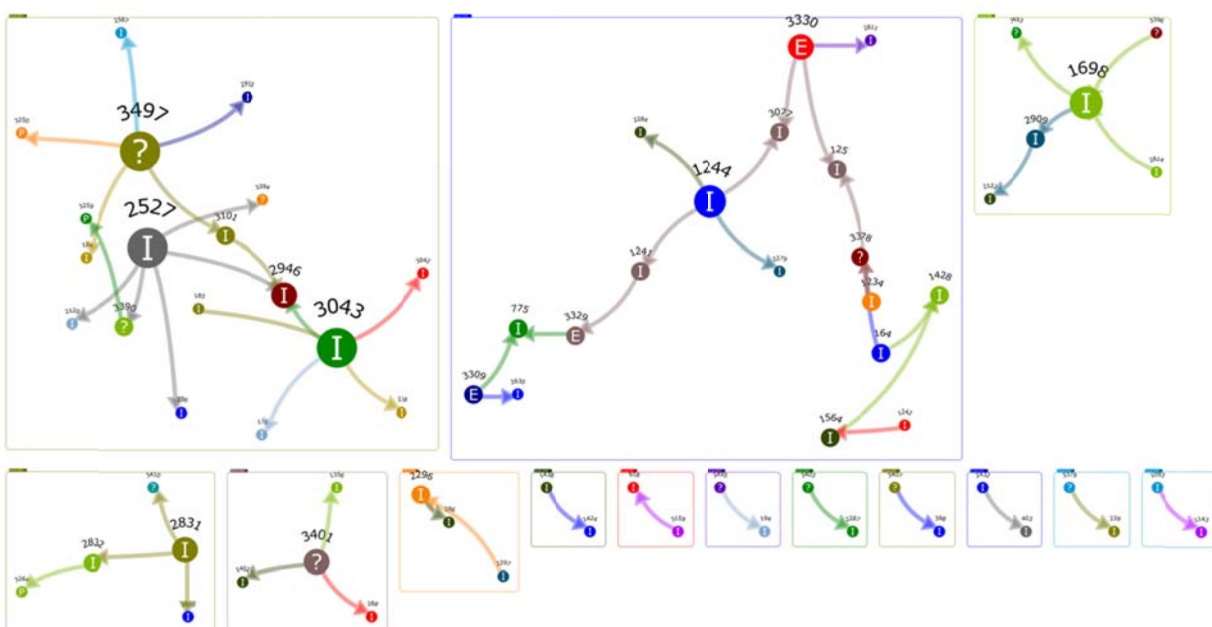

Figure 14. Octopus exchange networks.

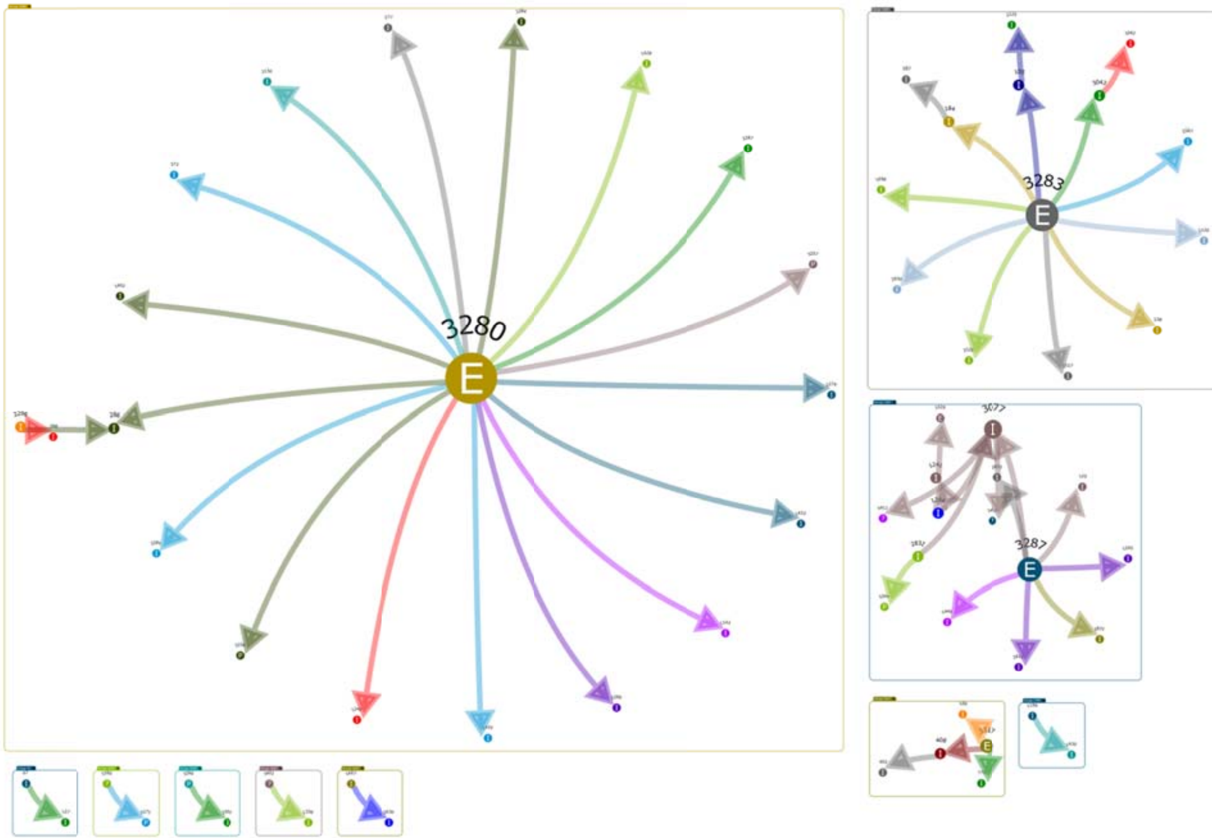

Figure 15. King crab networks are all based on access to crab from canneries, or from Costco in Anchorage demonstrating the negative impacts of crab rationalization on local peoples.

Table 17. Chiton networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	7	6	1	6	1	0	0	6	1	0	0
3	5	4	4	4	0	0	1	2	1	0	1
2	4	3	2	2	0	1	0	3	1	1	0
4	3	2	3	3	0	0	0	2	1	0	0
5	3	2	1	2	0	0	0	1	2	0	0
6	2	1	2	1	0	0	1	1	0	0	1
7	2	1	2	2	0	0	0	1	1	0	0
8	2	1	1	2	0	0	0	2	0	0	0
9	2	1	2	1	1	0	0	1	1	0	0
10	2	1	1	2	0	0	0	1	1	0	0
11	2	1	1	1	1	0	0	2	0	0	0
12	2	1	1	2	0	0	0	2	0	0	0
13	2	1	1	1	0	1	0	1	0	1	0

Table 18. Octopus networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	18	17	1	11	3	3	0	13	1	3	0
2	18	17	6	11	0	1	3	12	1	1	3
3	6	5	2	3	1	2	0	3	1	2	0
4	5	4	2	2	1	1	0	3	1	1	0
5	4	3	2	3	0	1	0	3	0	1	0
6	3	2	2	3	0	0	0	2	1	0	0
7	2	1	2	1	0	0	0	1	1	0	0
8	2	1	2	2	0	0	0	1	1	0	0
9	2	1	1	1	0	1	0	1	0	1	0
10	2	1	2	1	0	1	0	1	0	1	0
11	2	1	2	1	0	1	0	1	0	1	0
12	2	1	2	2	0	0	0	1	1	0	0
13	2	1	1	1	0	1	0	1	0	1	0
14	2	1	2	2	0	0	0	1	1	0	0

Table 19. King Crab networks

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	20	19	3	13	2	0	1	18	0	0	1
2	14	13	2	13	0	0	1	12	1	0	1
3	15	14	4	7	1	2	2	10	0	2	2
4	5	4	2	2	1	0	1	4	0	0	1
5	2	1	1	3	0	0	0	2	0	0	0
6	2	1	1	1	1	0	0	2	0	0	0
7	2	1	1	0	1	1	0	1	0	1	0
8	2	1	1	1	1	0	0	1	1	0	0
9	2	1	2	1	0	1	0	1	0	1	0
10	2	1	1	2	0	0	0	2	0	0	0

Sea mammals have a much smaller role in North Aleutian Basis subsistence today than in years past. But there are a couple of important sea mammal distribution networks (Figure 16). There is fairly widespread use of small seals in Akutan and Port Heiden. There was also a large redistribution of Steller sea lion in Akutan. There was a small harvest of fur seal, and a few otters taken as well. Whale meat was brought in from Barrow (Table 20). The largest sea mammal network is in the west, with Steller sea lions and seals being given in a network dominated by a single hunter (Figure 16). The second largest network is in Port Heiden and is mostly seals (Table 21). The mostly widely traded sea mammals are the small seals, which included six different communities. The Steller sea lion distribution was confined to a single community.

Looking specifically at the Steller sea lion network (Figure 17, Table 22), there is a large network with multiple nodes and interconnections. But criticial to this discussion, it is dominated by a single hunter, making it very vulnerable.

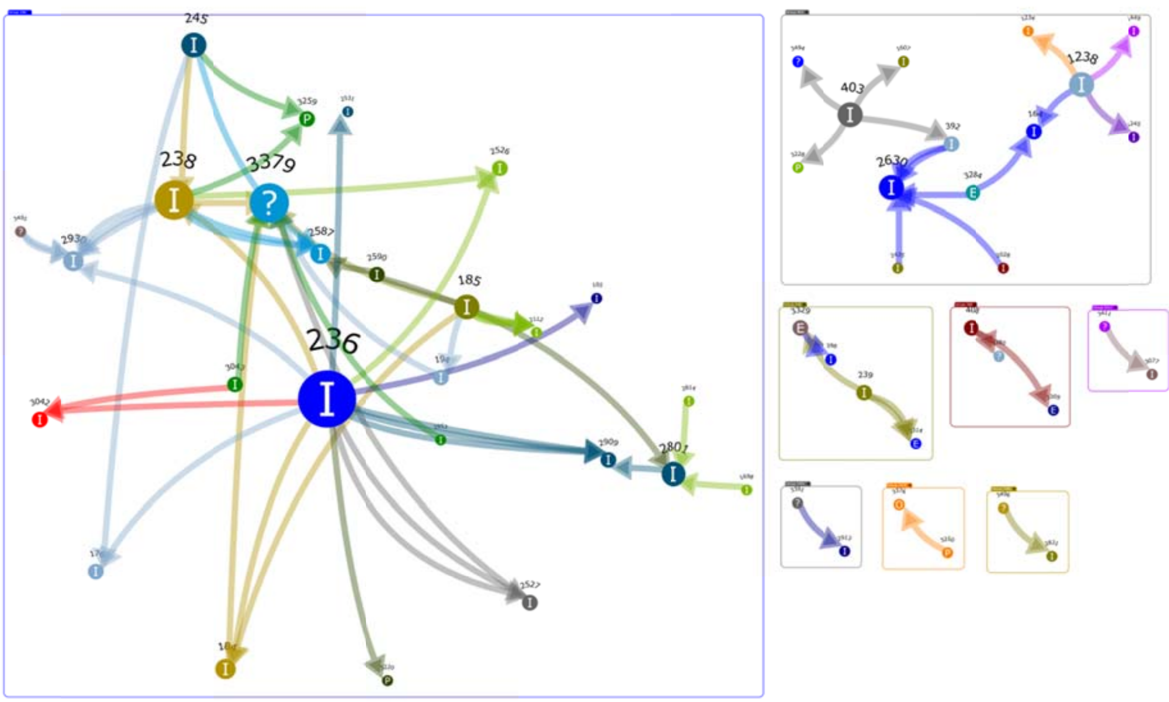

Figure 16. Sea mammal transaction networks.

Table 20. Sea mammal transactions based on limited sea mammal hunting in the region. Seals dominate the networks, but a widely-distributed Steller sea lion is an important part of the largest network.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Eumetopias jubatus	26	24	1	17	1	2	1	20	1	2	1
Phoca vitulina	33	23	6	19	2	5	3	19	4	5	3
family Phocidae	10	6	1	8	0	1	0	9	0	1	0
Callorhinus ursinus	8	6	2	6	0	2	0	5	1	2	0
suborder Pinniped	10	5	3	8	1	0	0	8	2	0	0
Balaena mysticetus	3	2	2	1	1	0	1	2	0	0	1
order Large Cetacea	4	2	4	2	0	1	1	2	0	1	1
Enhydra lutris	2	1	1	2	0	0	0	1	1	0	0
Odobenus rosmarus divergens	2	1	2	1	1	0	0	1	1	0	0

Table 21. Sea mammal transaction networks. Two primary, six small and local.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	26	46	2	19	2	2	0	22	1	2	0
2	14	14	5	7	3	1	1	7	4	1	1
3	4	4	3	2	0	0	2	2	0	0	2
4	3	2	2	1	0	1	1	1	0	1	1
5	2	1	1	0	1	1	0	1	0	1	0
6	2	1	1	1	0	1	0	1	0	1	0
7	2	1	1	1	0	1	0	1	0	1	0
8	2	1	2	1	0	1	0	1	0	1	0

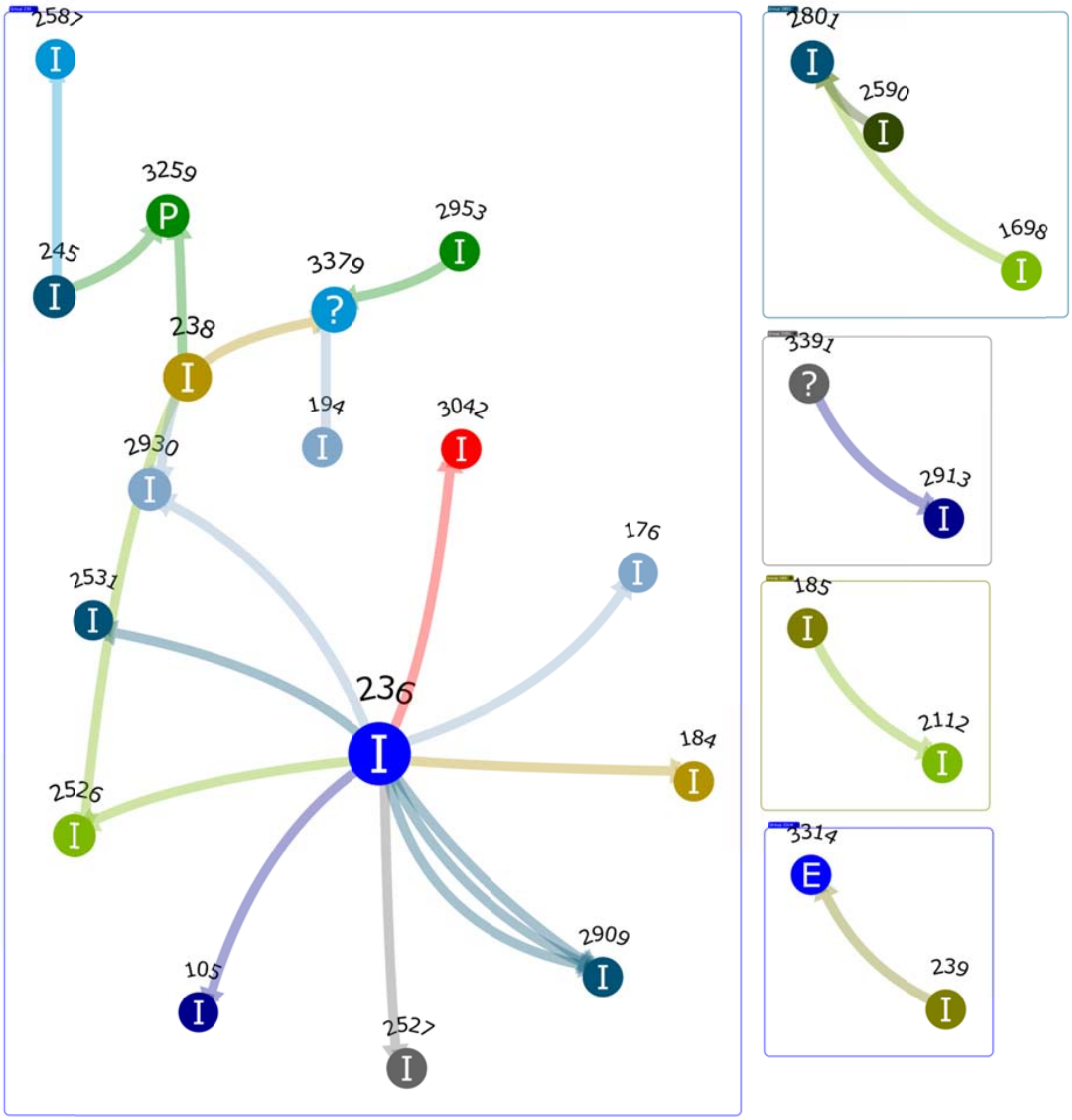

Figure 17. Sea lion exchange networks.

Table 22. Sea lion networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	17	19	1	12	1	1	0	14	1	1	0
2	3	2	1	3	0	0	0	3	3	0	0
3	2	1	1	1	0	0	1	1	1	0	1
4	2	1	1	2	0	1	0	2	1	1	0
5	2	1	1	2	0	0	0	1	2	0	0

Perhaps the strangest and most artificial networks in the entire study are those involving the distribution of terrestrial mammals (Figure 18). The largest two networks are classic star networks, dominated by a single provider. The third largest is a complex interconnected cluster type. The three top species of terrestrial mammal in these transactions are moose, caribou, and cow (Table 23). Other species are rare.

While there are a large number of small networks involving terrestrial mammals (Table 24), most are very small. Looking at the largest networks, we find the caribou exchange network to have the most durable and resilient structure (Figure 19, Table 25). Multiple nodes with multiple connections spread out over several communities make this a very strong network. In contrast, the moose redistribution networks are completely different from the caribou networks (Figure 20, Table 26). With most moose there is little local harvest. Rather, the “E” designation in the largest network is “sport hunters” who distribute moose meat taken on guided hunts. This is the case for 3 of the 4 largest networks. Should sport hunting for moose disappear, the bulk of moose meat coming into these communities would cease as well. Therefore these networks are vulnerable to changing game regulations. The most vulnerable terrestrial mammal networks are the redistribution of cattle meat (Figure 21, Table 27). More than 90 percent of the meat flowing through the cattle network comes through a single individual.

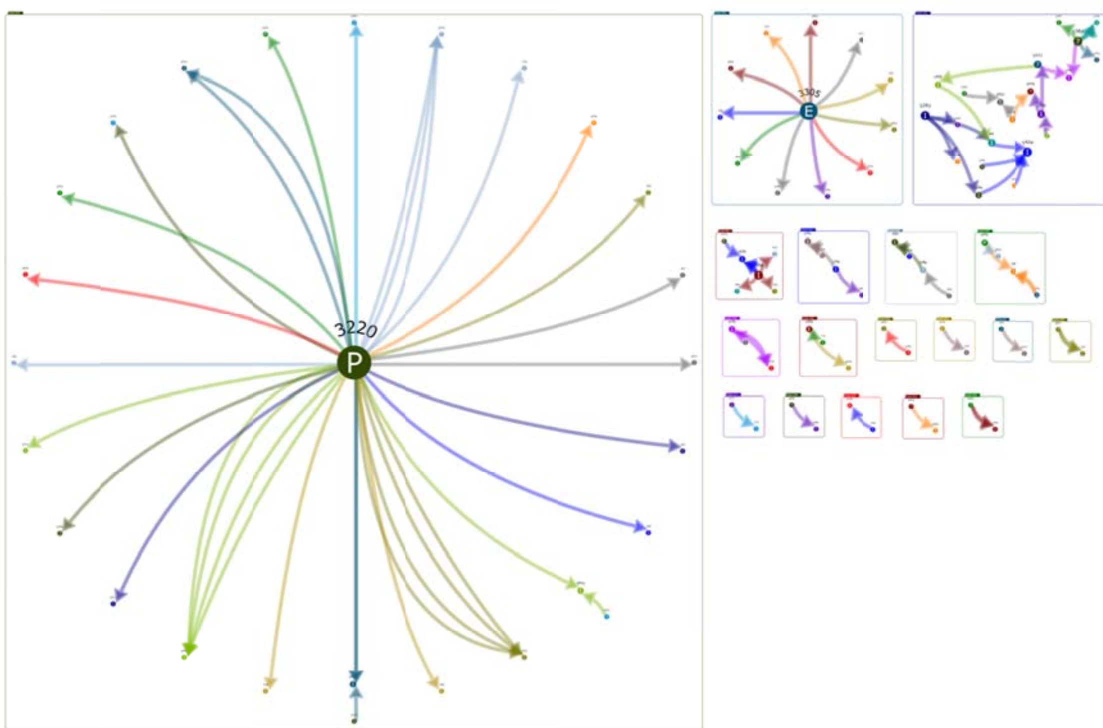

Figure 18. Terrestrial mammal networks are dominated by transactions involving wild cattle or caribou. The largest network is a cattle distribution with the primary node an individual outside the regional genealogical system. The second network is centered around sport hunters who redistribute their kills to local communities. The third network is a complex system of redistribution based on the limited moose and caribou supply in the region.

Table 23. Terrestrial species in regional transaction networks.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Alces alces	39	33	9	26	4	5	2	27	3	5	2
Rangifer tarandus	38	28	8	25	0	5	2	21	7	5	2
Bos sp.	34	39	3	19	5	3	1	28	2	3	1
Erethizon dorsatum	2	1	1	1	0	1	0	1	0	1	0
Bison bison	2	1	2	1	0	1	0	1	0	1	0
Lepus othus	2	1	2	1	0	1	0	1	0	1	0

Table 24. Terrestrial mammal exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	27	36	2	14	5	2	0	24	1	2	0
3	21	23	4	15	1	3	0	14	0	3	0
2	12	11	2	9	0	0	1	11	2	0	1
4	6	7	1	3	0	0	1	3	1	0	1
5	4	4	2	3	2	0	0	3	1	0	0
6	4	3	1	2	0	2	0	2	0	2	0
7	4	3	2	3	0	0	1	3	0	0	1
9	3	3	2	3	0	0	0	1	0	0	0
8	3	2	2	2	0	0	1	2	2	0	1
11	2	2	2	1	0	1	0	1	1	1	0
16	2	2	2	1	0	1	0	1	0	1	0
10	2	1	2	2	1	0	0	1	0	0	0
12	2	1	2	0	0	1	0	1	1	1	0
13	2	1	2	2	0	0	0	1	1	0	0
14	2	1	1	2	0	0	0	1	1	0	0
15	2	1	1	2	0	0	0	1	0	0	0
17	2	1	1	1	0	0	1	1	0	0	1
18	2	1	1	1	0	1	0	1	0	1	0

Figure 19. Caribou exchange networks.

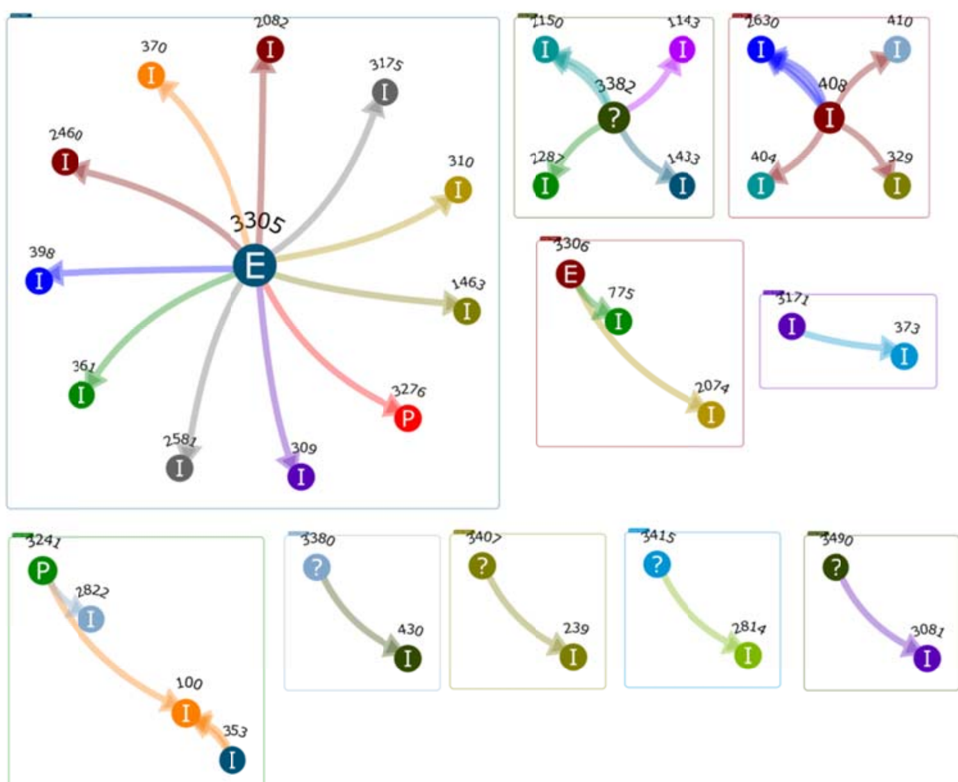

Figure 20. Moose exchange networks.

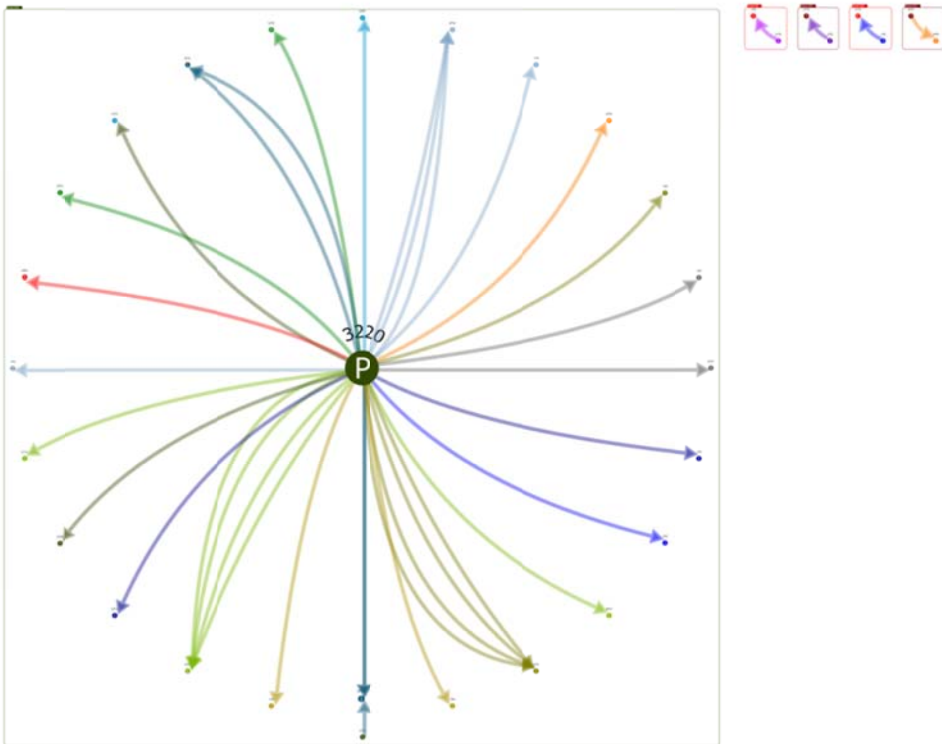

Figure 21. Cattle distribution networks.

Table 25. Caribou exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	13	13	3	10	0	1	0	9	1	1	0
2	4	3	2	3	0	0	1	3	0	0	1
3	4	3	1	3	0	1	0	2	1	1	0
4	3	2	2	3	0	0	0	1	2	0	0
5	2	1	2	1	0	1	0	1	0	1	0
6	2	1	2	2	0	0	0	1	1	0	0
7	2	1	1	2	0	0	0	1	1	0	0
8	2	1	1	1	0	0	1	1	0	0	1
9	2	1	1	1	0	1	0	1	0	1	0
10	2	1	1	2	0	0	0	1	1	0	0
11	2	1	2	1	0	1	0	1	0	1	0

Table 26. Moose exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	12	11	2	9	1	0	1	11	0	0	1
2	5	5	2	5	0	1	0	4	0	1	0
3	5	6	1	3	0	0	0	3	1	0	0
4	4	4	2	3	2	0	0	3	1	0	0
5	3	2	2	2	0	0	1	2	0	0	1
6	2	1	2	2	0	0	0	1	1	0	0
7	2	1	1	1	0	1	0	1	0	1	0
8	2	1	2	1	0	1	0	1	0	1	0
9	2	1	2	1	0	1	0	1	0	1	0
10	2	1	2	0	1	1	0	1	0	1	0

Table 27. Cattle distribution networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	26	35	1	14	5	1	0	24	1	1	0
2	2	1	2	2	0	0	0	1	1	0	0
3	2	1	1	1	0	1	0	1	0	1	0
4	2	1	1	1	0	0	1	1	0	0	1
5	2	1	1	1	0	1	0	1	0	1	0

The bird networks include marine birds, migratory waterfowl, and upland birds. The two most active taxa or classes in these networks of exchange are ptarmigan and gull eggs (Table 28). Also included in these networks are eggs (mostly gull eggs). One major network (Figure 22), eight medium networks, and a large number of small networks are included (Table 29). The ptarmigan and gull egg networks have very different structures. While both are village-based networks, gull egg networks have more interconnectedness, at least the large one (Figure 23, Table 30). The ptarmigan networks are simply a single hunter making 1-3 transactions (Figure 24, Table 31).

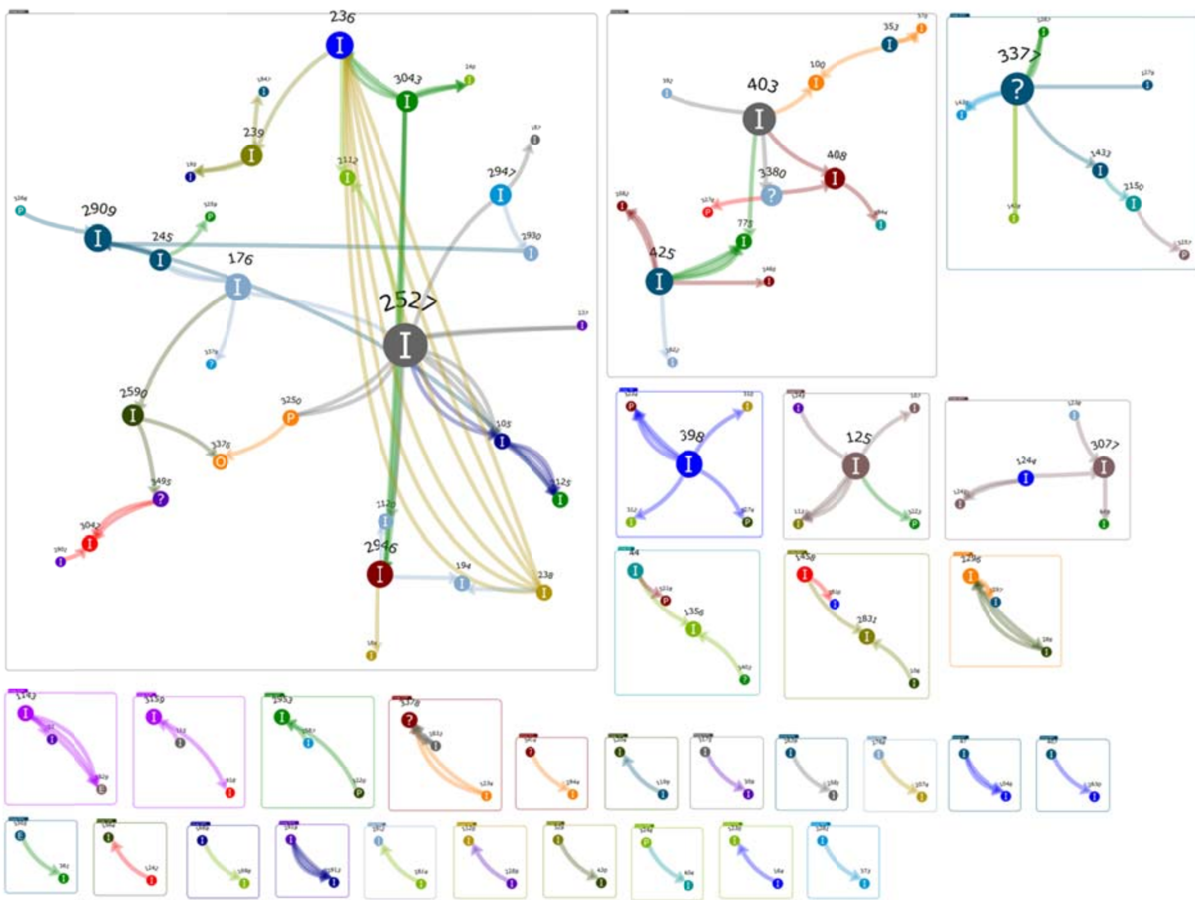

Figure 22. Exchange networks for birds and bird eggs.

Table 28. Bird and bird egg taxa represented in the networks. The two most important species in these data are ptarmigan and gull eggs.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Larus sp.	59	41	8	37	4	6	0	39	10	6	0
Lagopus sp.	50	28	10	37	6	2	2	30	12	2	2
Anatidae family	28	17	8	22	1	3	1	18	6	3	1
Branta bernicla	16	12	5	10	4	1	0	10	3	1	0
Chen canagica	17	9	6	15	1	1	1	11	3	1	1
Rock Duck	13	9	2	9	2	1	0	8	3	1	0
Branta canadensis	13	7	5	9	1	3	0	10	0	3	0
Fratercula sp.	10	7	1	7	0	0	0	7	3	0	0
Anas crecca	8	5	2	6	2	0	0	5	3	0	0
Histrionicus histrionicus	7	4	1	5	1	0	0	4	3	0	0
Melanitta sp.	7	4	2	6	1	0	0	4	2	0	0
Anas platyrhynchos	4	2	3	4	0	0	0	2	2	0	0
Unknown Goose	4	2	1	3	0	1	0	3	0	1	0
Aythya afinis	2	1	1	2	0	0	0	2	0	0	0
Bucephala albeola (Bufflehead)	2	1	1	1	1	0	0	2	0	0	0
Bucephala clangula	2	1	1	2	0	0	0	1	1	0	0
Grus canadensis	2	1	1	1	0	1	0	1	0	1	0
Sterna sp.	2	1	1	2	0	0	0	2	0	0	0

Table 29. Bird and egg exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	31	59	3	17	4	3	0	18	7	3	0
2	14	19	2	11	2	1	0	9	3	1	0
3	8	11	1	5	1	1	0	7	0	1	0
4	5	6	2	2	2	0	0	3	2	0	0
5	5	6	2	3	1	0	0	3	2	0	0
6	5	5	2	4	0	0	0	4	1	0	0
7	4	3	3	2	1	1	0	3	0	1	0
8	4	3	4	3	1	0	0	1	3	0	0
9	3	2	2	3	0	0	0	1	2	0	0
10	3	5	2	3	0	0	0	2	1	0	0
11	3	4	2	2	1	0	1	1	0	0	1
12	3	2	1	2	1	0	0	3	0	0	0
13	3	6	1	2	0	1	0	2	0	1	0
14	2	4	1	2	0	0	0	1	1	0	0
15	2	1	1	1	0	1	0	1	0	1	0
16	2	1	1	2	0	0	0	1	0	0	0
17	2	1	1	1	1	0	0	2	0	0	0
18	2	1	1	2	0	0	0	2	0	0	0
19	2	1	1	1	1	0	0	2	0	0	0
20	2	2	1	1	1	0	0	2	0	0	0
21	2	1	1	2	0	0	0	2	0	0	0
22	2	1	2	1	0	0	1	1	0	0	1
23	2	1	2	2	0	0	0	1	1	0	0
24	2	1	1	2	0	0	0	1	1	0	0
25	2	1	1	2	0	0	0	1	1	0	0
26	2	1	1	2	0	0	0	1	1	0	0
27	2	1	1	2	0	0	0	1	1	0	0
28	2	1	1	1	1	0	0	1	1	0	0
29	2	1	1	2	0	0	0	1	0	0	0
30	2	1	1	2	0	0	0	2	0	0	0

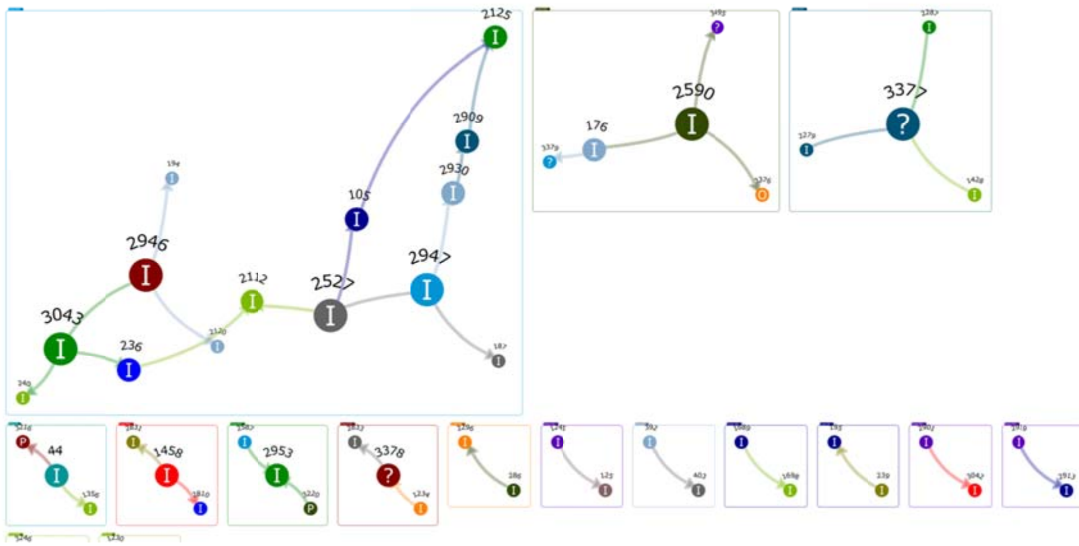

Figure 23. Gull egg redistribution networks.

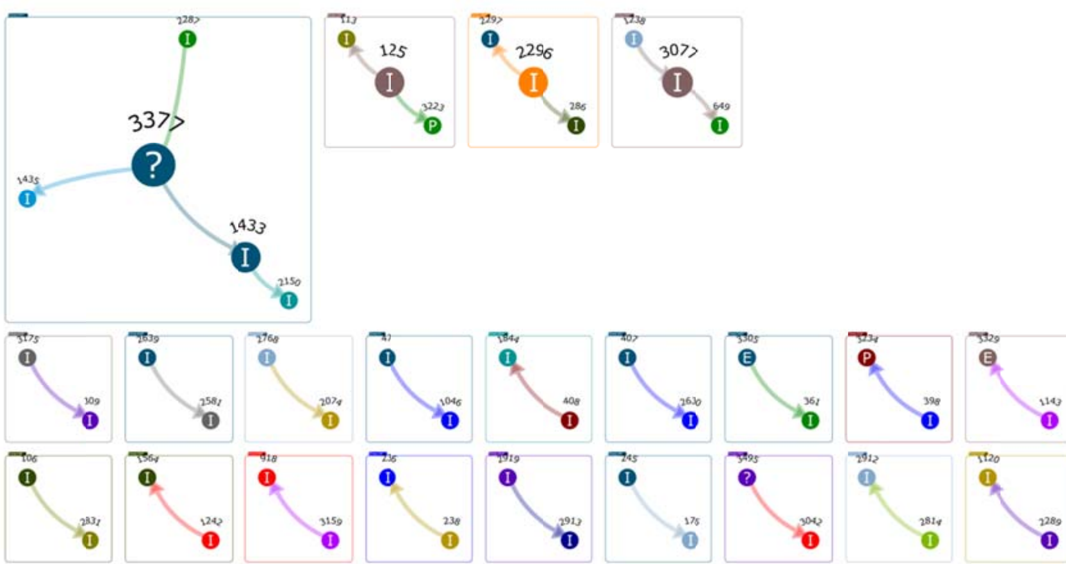

Figure 24. Ptarmigan redistribution networks.

Table 30. Gull egg exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	15	16	2	12	0	0	0	13	2	0	0
2	5	4	1	2	0	3	0	2	0	3	0
3	4	3	1	3	0	1	0	3	0	1	0
4	3	2	2	2	1	0	0	3	0	0	0
5	3	2	3	2	1	0	0	1	2	0	0
6	3	2	1	2	1	0	0	3	0	0	0
7	3	2	1	2	0	1	0	2	0	1	0
8	2	1	1	1	0	1	0	1	0	1	0
9	2	1	1	2	0	0	0	2	0	0	0
10	2	1	2	2	0	0	0	2	0	0	0
11	2	1	1	2	0	0	0	1	1	0	0
12	2	1	1	2	0	0	0	1	1	0	0
13	2	1	1	2	0	0	0	1	1	0	0
14	2	1	1	2	0	0	0	1	1	0	0
15	2	1	1	2	0	0	0	1	1	0	0
16	2	1	1	1	1	0	0	1	1	0	0
17	2	1	1	2	0	0	0	1	0	0	0

Table 31. Ptarmigan exchange networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	5	4	1	3	0	1	0	4	0	1	0
2	3	2	2	2	1	0	0	2	1	0	0
3	3	2	2	3	0	0	0	2	1	0	0
4	3	2	2	3	0	0	0	2	1	0	0
5	2	1	1	1	1	0	0	2	0	0	0
6	2	1	1	2	0	0	0	2	0	0	0
7	2	1	1	1	1	0	0	2	0	0	0
8	2	1	1	1	1	0	0	2	0	0	0
9	2	1	2	1	1	0	0	1	1	0	0
10	2	1	1	2	0	0	0	2	0	0	0
11	2	1	2	1	0	0	1	1	0	0	1
12	2	1	2	1	1	0	0	1	1	0	0
13	2	1	2	2	0	0	1	1	0	0	1
14	2	1	2	2	0	0	0	1	1	0	0
15	2	1	2	2	0	0	0	1	1	0	0
16	2	1	2	2	0	0	0	1	1	0	0
17	2	1	1	2	0	0	0	1	1	0	0
18	2	1	1	2	0	0	0	1	1	0	0
19	2	1	1	2	0	0	0	2	0	0	0
20	2	1	1	1	0	1	0	1	0	1	0
21	2	1	1	2	0	0	0	1	1	0	0
22	2	1	1	2	0	0	0	1	1	0	0

The most important plant foods exchanged are salmonberry, crowberry, and three species of *Vaccinium*, which may all be the same plant with different local names (Table 32). The network redistribution of wild plants includes two larger networks, seven networks with 5-8 nodes, and a large number of smaller networks (Figure 25, Table 33). While some plant foods move between villages, these networks are very local, with foods moving between families within villages. The most important differences between these networks and all others are that the primary nodes are women in most of these networks.

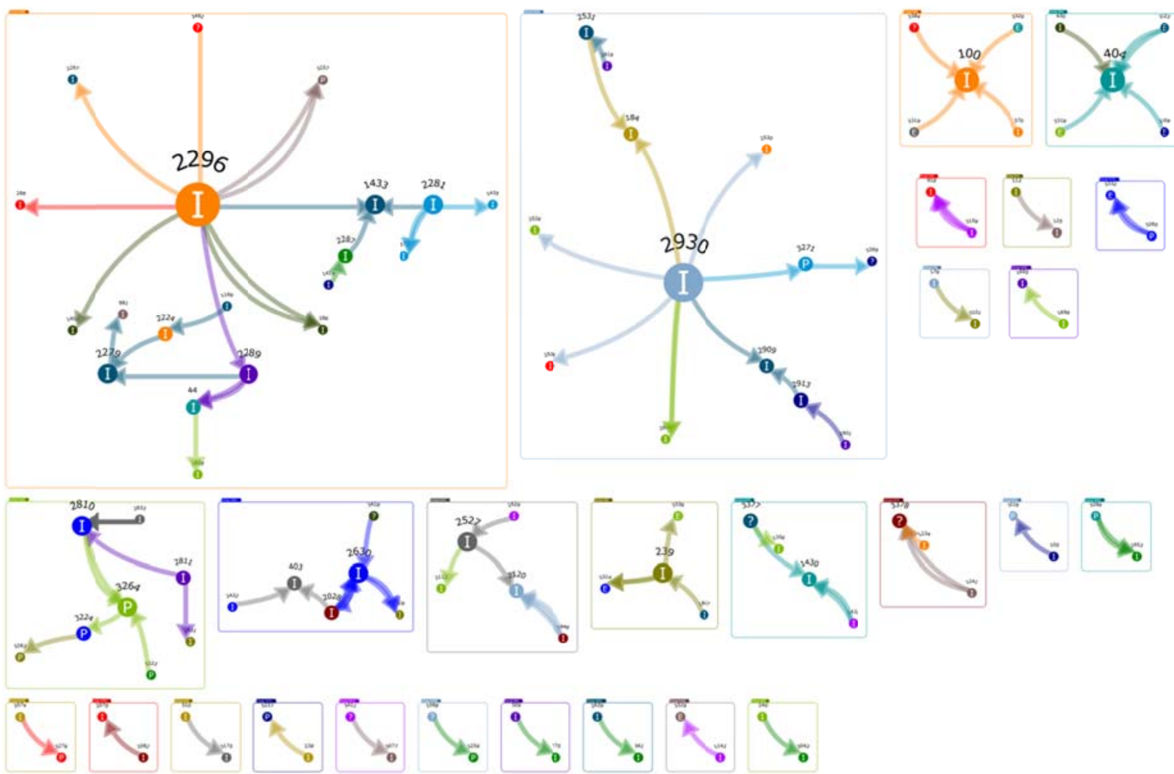

Figure 25. Wild plant food redistribution networks.

Table 32. Plant food data based on the networks. The dominant plants are up to three species of *Vaccinium* -- various forms of bog, cowberry, and blueberry which may all be the same species with different regional names. Also important are what is referred to salmonberry and crowberry.

Taxon	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Vaccinium vitis-idaea	4	2	3	3	1	0	0	3	1	0	0
Vaccinium uliginosum	17	11	4	8	6	0	1	8	6	0	1
Frageria chiloensis	9	8	3	8	0	1	0	7	0	1	0
Vaccinium ovalifolium	7	4	2	6	1	0	0	5	2	0	0
Rubus chamaemorus	37	36	9	21	6	2	4	20	8	2	4
Empetrum nigrum	44	45	10	24	4	4	3	29	3	4	3
Mushrooms	2	1	1	0	1	1	0	1	0	1	0
Heracleum lanatum	5	3	3	3	0	0	1	2	1	0	1
Ligusticum scoticum	10	8	3	6	0	0	1	7	1	0	1
Wineberries	5	3	2	3	1	0	1	3	0	0	1
Tundra Tea	3	2	1	2	0	0	0	2	0	0	0
Honchenya peploides	3	2	2	1	1	0	0	1	1	0	0
Huckleberries	5	3	2	3	1	0	1	2	2	0	1
Athyrium felix-famine	2	1	2	1	1	0	0	1	1	0	0
Polygonum alpinum	9	5	2	6	0	2	0	6	0	2	0
Epilobium angustifolium	8	7	2	4	1	0	0	5	2	0	0
Berries-unknown	9	5	3	8	0	0	0	8	1	0	0

Table 33. Plant networks.

Network	Nodes	Transactions	Communities	Families	Non-Family nodes (P, I)	Non-Family nodes (?, O)	Non-Family nodes (E)	Households	Non-Household nodes (P, I)	Non- Household nodes (?, O)	Non-Household nodes (E)
1	20	23	3	13	1	1	0	14	2	1	0
2	13	13	2	6	1	1	0	8	4	1	0
3	5	4	4	1	1	1	2	2	0	1	2
4	5	5	4	2	0	0	3	2	0	0	3
5	8	12	2	2	4	0	0	5	2	0	0
6	6	9	3	4	1	1	0	2	3	1	0
7	5	6	1	4	0	0	0	5	0	0	0
8	4	4	2	2	0	0	2	1	1	0	2
9	4	4	1	4	0	1	0	3	0	1	0
10	3	3	1	1	0	1	0	2	0	1	0
11	2	1	2	1	1	0	0	1	1	0	0
12	2	2	1	1	1	0	0	1	1	0	0
13	2	3	2	2	0	0	0	1	1	0	0
14	2	1	1	2	0	0	0	1	1	0	0
15	2	2	1	0	1	0	1	1	0	0	1
16	2	1	1	2	0	0	0	2	0	0	0
17	2	1	1	2	0	0	0	2	0	0	0
18	2	1	1	0	1	1	0	1	0	1	0
19	2	1	1	2	0	0	0	2	0	0	0
20	2	1	1	2	0	0	0	2	0	0	0
21	2	1	1	1	1	0	0	2	0	0	0
22	2	1	2	1	1	0	0	1	1	0	0
23	2	1	2	1	0	1	0	1	0	1	0
24	2	1	1	1	1	0	0	2	0	0	0
25	2	1	1	2	0	0	0	1	1	0	0
26	2	1	2	2	0	0	1	1	0	0	1
27	2	1	1	2	0	0	0	2	0	0	0

HOUSEHOLD NETWORKS

Now that the individual networks have been described, the next level is the household data. The household data are where the critical transactions take place. In many ways, the individual networks are similar to the household networks, except that individuals and families are now lumped into larger entities. The household networks appear to be more coherent – smaller numbers of nodes that are better connected.

This requires introducing a new index. The point of this index is to measure the rate of return on transactions. This is important. In all systems of exchange one would expect some reciprocal exchange where one person gives away fresh salmon, for example, and gets smoked salmon or strips in return. Or they might get something else in return for the salmon, such as gull eggs, octopus, or even beef. The ***return index*** (RI) is a measure of that return. For example, if a household has 26 transactions out, and 15 transactions in, then 15-26= -11 in return: their *return index* is -11. If a household has 5 transactions out, but takes in 19, then 19-5=14, a much larger *return index*. This is a critical index for measuring inter-household transactions. Because of the importance of the household data, and for making future comparisons between households, this analysis also provides basic statistics, bar charts, and correlation coefficient tables for all data presented.

Figure 26 is the combined regional network for all households and attached individuals and entities in the study region. Every household in the project area is connected in one large combined network except for two. This one massive network has 230 nodes, over 1000 transactions, and involves 87 households and 143 individuals / entities in 31 communities (Table 34). Table 35 lists all of the households and individuals without household status, sorted by the number of transactions out of the household. Here we recognized that there is not a single member of the network that does not have at least 5 transactions out. But we also see in the last column that there are a number of entries with zero transactions in. Does this mean that they received nothing in exchange? This is unclear because of the nature of these data. Many of these are individuals outside of the survey households. It is likely that people reported receiving foods from them, but we have less data on what might have been sent or given to them. Since we are looking at all transactions, the bulk effect should mitigate small inconsistencies in reporting.

Table 36 provides the correlation coefficients for the network categories. All categories of data are highly correlated, but with only three networks, these relationships are not as powerful as they will be below when there are a great number of networks for individual categories of resources.

Table 37 provides the descriptive statistics for all species included in the transactions. For the 82 different taxa and classifications included in these data, 16.24 is the average number of nodes involved in each taxa with a range from 2 to 108, and 12.48 is the mean number of transactions for each of these taxa with a range from 1 to 118. These considerable ranges are a measure of the importance of some species over others.

There is also a considerable range in the connectedness of some households over others (Table 38), where the average number of connected nodes for a household is 4.67, with an average of 8.67 transactions. Therefore the range (minimum-maximum) and Sample Variance is very high.

A good way to look at these data is to compute the return index for the top providers in the dataset. Table 39 provides the transaction data for the top 24 providers, including all households, non-household individuals, and other entities, with the return index computed for each. Here we see that the top 20 of 24 providers have a negative return index, with an average return index of (-11.5). Conversely, we see the opposite data for the top 24 receivers (Table 40). Except for a couple of households / individuals who are both top providers and top receivers, most of the top receivers have a return index in positive values – they get more than they give (mean = 5.5).

One concern might be the potential biasing effects of the non-surveyed, non-household nodes in these networks. To measure this, Table 41 provides that descriptive statistics for the combined household network for just the households surveyed on the project. When compared with Table 38, we find that all mean values are approximately twice what they were when all entities from all transactions were summarized. For example, the mean number of transactions for a household changes from 8.67 to 16.31. The mean number of connected nodes rises from 4.67 to 8.45, with similar changes across the table.

Therefore, we computed the return index for the top 20 and top 40 surveyed household respectively. These data show, at least for the top 20, that the surveyed household index is very similar to the combined household and non-surveyed individual data presented in Tables 39 and 40. Here we find that the top 20 households have a return index of -10.8, almost identical to the return index of -11.5 described above for all nodes in the network (Table 41). For the top 20 receivers, that is an average return index of 4.25, again very close to the mean of 5.5 for the combined data. When including the top 40 providers and receivers as a further exercise in data quality, and this now includes nearly half of the surveyed households, one finds that the numbers are still trending in the expected direction where the top providers give more than they receive, and vice versa (Table 43).

This analysis provides a firm justification for using the combined network node data that includes all transactions for all surveyed households and non-surveyed individuals. For the remainder of this section, we use the combined data as we look at certain classifications of taxa.

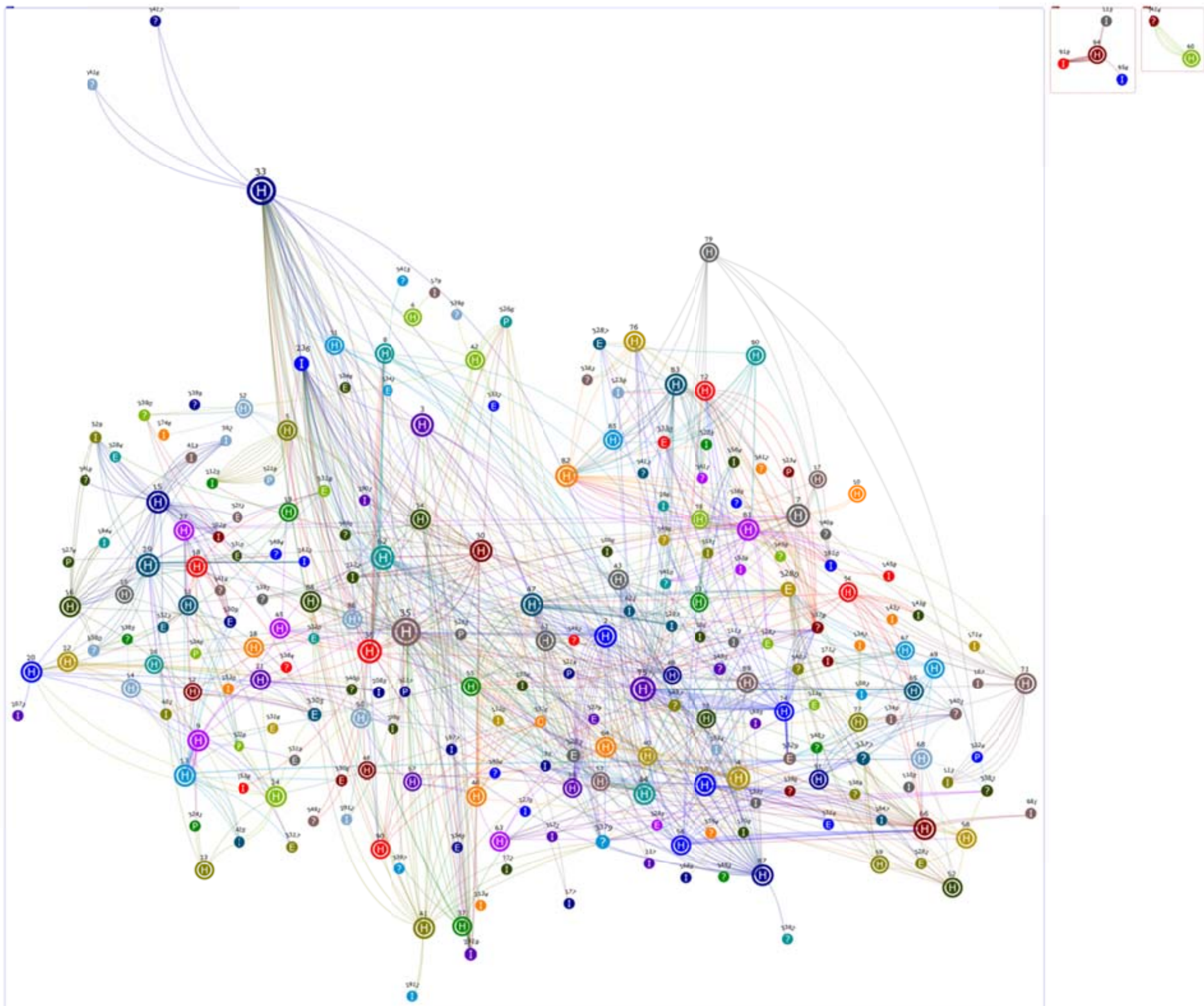

Figure 26. Network structure of households and their transactions.

Table 34. The structure of the three networks encompassing the household transactions.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	230	1006	31	87	73	43	27
2	4	12	2	1	3	0	0
3	2	5	1	1	0	1	0

Table 35. Example of household data sorted by numbers of transactions given out or sold.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In
33	1	28	55	50	5
35	1	28	59	42	17
75	1	20	45	39	8
62	1	18	45	34	13
87	1	11	34	28	6
3280	1	17	27	27	0
47	1	13	39	26	13
29	1	16	32	23	9
236	1	16	35	22	13
82	1	13	33	21	14
7	1	15	24	20	4
2	1	13	34	18	16
16	1	10	20	15	5
72	1	7	17	15	2
71	1	11	23	14	9
5	1	7	23	14	9
38	1	13	24	13	11
4	1	14	24	13	11
36	1	17	33	12	21
13	1	11	29	12	17
81	1	12	26	12	14
83	1	12	25	12	13
3305	1	11	12	12	0
3283	1	10	12	12	0
41	1	11	21	11	10
8	1	8	17	11	6
88	1	9	14	11	3
52	1	7	14	11	3
2919	1	5	13	11	2
3330	1	7	11	10	1
3309	1	5	11	10	1
74	1	6	30	9	21
3	1	14	18	9	9
76	1	11	15	9	6
24	1	10	14	9	5
84	2	3	12	9	3
15	1	14	34	8	26
3377	1	11	20	8	12
46	1	8	18	8	10
56	1	7	17	8	9
50	1	8	10	8	4
3266	1	5	11	8	3
425	1	4	9	8	1
3287	1	8	8	8	0
66	1	13	26	7	19
3495	1	5	10	7	3
3401	1	5	9	7	2
49	1	8	14	6	10
68	1	10	14	6	8
54	1	7	14	6	8
2122	1	5	9	6	3
2028	1	2	8	6	2
3382	1	4	6	6	0
3378	1	5	24	5	19

Table 36. Correlation coefficients for the complete data that is sampled in Table 67.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.981	1.000					
Communities	0.884	0.825	1.000				
Households	0.992	0.974	0.859	1.000			
Non- Household nodes (P, I)	0.864	0.837	0.796	0.807	1.000		
Non- Household nodes (?, O)	0.909	0.890	0.815	0.889	0.720	1.000	
Non- Household nodes (E)	0.829	0.822	0.801	0.814	0.635	0.746	1.000

Table 37. Descriptive statistics for all species transactions.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Mean	16.24	12.48	3.83	10.91	2.71	1.74	0.88
Standard Error	2.33	2.20	0.35	1.58	0.43	0.28	0.16
Median	8.00	4.00	3.00	5.00	1.00	1.00	0.00
Mode	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Standard Deviation	21.09	19.94	3.13	14.31	3.90	2.57	1.44
Sample Variance	444.63	397.46	9.80	204.67	15.17	6.61	2.08
Kurtosis	5.85	11.79	1.02	5.02	6.40	5.93	5.36
Skewness	2.30	3.11	1.30	2.20	2.29	2.34	2.24
Range	106.00	117.00	13.00	69.00	21.00	12.00	7.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	108.00	118.00	14.00	70.00	21.00	12.00	7.00
Sum	1332.00	1023.00	314.00	895.00	222.00	143.00	72.00
Count	82.00	82.00	82.00	82.00	82.00	82.00	82.00
Confidence Level(95.0%)	4.63	4.38	0.69	3.14	0.86	0.57	0.32

Table 38. Descriptive statistics for all households in the networks, including all entities with which the households conducted transactions from Table 67.

	Nodes	*Transactions*	*Transactions Out*	*Transactions In*
Mean	4.67	8.67	4.36	4.36
Standard Error	0.31	0.66	0.46	0.35
Median	3.00	5.00	2.00	2.00
Mode	1.00	1.00	1.00	0.00
Standard Deviation	4.74	10.16	7.09	5.35
Sample Variance	22.50	103.22	50.25	28.66
Kurtosis	4.49	5.03	14.01	2.06
Skewness	1.84	2.06	3.35	1.54
Range	27.00	58.00	50.00	26.00
Minimum	1.00	1.00	0.00	0.00
Maximum	28.00	59.00	50.00	26.00
Sum	1101.00	2046.00	1028.00	1028.00
Count	236.00	236.00	236.00	236.00
Confidence Level(95.0%)	0.61	1.30	0.91	0.69

Table 39. Data for the top 24 providers in the entire household dataset.

Person	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
33	1	28	55	50	5	-45
35	1	28	59	42	17	-25
75	1	20	45	39	8	-31
62	1	18	45	34	13	-21
87	1	11	34	28	6	-22
3280	1	17	27	27	0	-27
47	1	13	39	26	13	-13
29	1	16	32	23	9	-14
236	1	16	35	22	13	-9
82	1	13	33	21	14	-7
7	1	15	24	20	4	-16
2	1	13	34	18	16	-2
72	1	7	17	15	2	-13
16	1	10	20	15	5	-10
71	1	11	23	14	9	-5
5	1	7	23	14	9	-5
38	1	13	24	13	11	-2
4	1	14	24	13	11	-2
3305	1	11	12	12	0	-12
3283	1	10	12	12	0	-12
83	1	12	25	12	13	1
81	1	12	26	12	14	2
36	1	17	33	12	21	9
13	1	11	29	12	17	5
INDEX OF RETURN (mean)						-11.5

Table 40. Data for the top 24 receivers in the household transaction dataset.

Person	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
15	1	14	34	8	26	18
30	1	13	25	2	23	21
36	1	17	33	12	21	9
74	1	6	30	9	21	12
66	1	13	26	7	19	12
3378	1	5	24	5	19	14
9	1	11	22	3	19	16
43	1	8	20	1	19	18
44	1	11	21	3	18	15
39	1	5	18	0	18	18
35	1	28	59	42	17	-25
13	1	11	29	12	17	5
3379	1	13	21	4	17	13
2	1	13	34	18	16	-2
3329	1	7	19	4	15	11
82	1	13	33	21	14	-7
81	1	12	26	12	14	2
62	1	18	45	34	13	-21
47	1	13	39	26	13	-13
236	1	16	35	22	13	-9
83	1	12	25	12	13	1
3377	1	11	20	8	12	4
2810	1	5	14	2	12	10
18	1	10	14	2	12	10
INDEX OF RETURN (mean)						5.5

Table 41. Descriptive statistics for only the 89 households surveyed.

	Nodes	*Transactions*	*Transactions Out*	*Transactions In*
Mean	8.45	16.31	7.69	8.74
Standard Error	0.53	1.23	1.03	0.56
Median	8.00	13.00	4.00	8.00
Mode	8.00	10.00	0.00	8.00
Standard Deviation	4.97	11.57	9.69	5.28
Sample Variance	24.66	133.90	93.81	27.92
Kurtosis	4.00	2.46	5.92	1.01
Skewness	1.56	1.49	2.29	1.12
Range	27.00	57.00	50.00	25.00
Minimum	1.00	2.00	0.00	1.00
Maximum	28.00	59.00	50.00	26.00
Sum	752.00	1452.00	684.00	778.00
Count	89.00	89.00	89.00	89.00
Confidence Level(95.0%)	1.05	2.44	2.04	1.11

Table 42. Return index values for the top 20 and 40 providers and receivers using only the surveyed households.

	Return Index: Transactions Out	Return Index: Transactions In
Top 20	-10.8	4.25
Top 40	-4.875	3.025

Household Salmon Networks

Beginning with the salmon-based transactions, Figure 27 shows the visual power of these types of analyses. There are three large networks, three intermediate networks, and 8 small networks. The relative sizes of the nodes are an indicator of the number connections to that node. The network size variation is quantified in Table 43, and the rapid decay in network size is seen in Figure 28. In these data we find that there is considerable connectedness across the region, with 40 households and 19 others from a total of 8 communities connected in one large network of salmon-based transactions. We would also expect that the largest networks would have the greatest resilience as well, and be less vulnerable to the loss of a participating household. Half of the 14 networks have only one household and one non-household participant, which would be highly vulnerable to the loss of the single member.

In Table 44 we provide the correlation coefficients for the network data in Table 43. Here we find that nodes, transactions, households, and non-household persons/individuals (P,I) are all highly correlated (r=>.96). But we find that numbers of communities are less correlated, and non-household communities and entities are less so. This means two things with salmon. First, there was a clear memory of who was involved in the transactions – fewer responses of “gave to everyone in the village,” or received from “friends in Chignik,” for example. Second, it means that canneries and stores play little role in access to salmon, at least directly.

Table 45 provides the network data for five species of salmon. It is clear, as it was in the individual networks, that sockeye are the most important species in these transactions and form the largest part of the network structures. A rank order chart of the five taxa is presented in Figure 29.

In Tables 46 and 47, we list the top 20 providers (RI = -4.25) and the top 20 receivers (RI = 2.55). These numbers are closer to zero than the combined network averages presented above, indicating that salmon transactions are more balanced than some other taxa in the data.

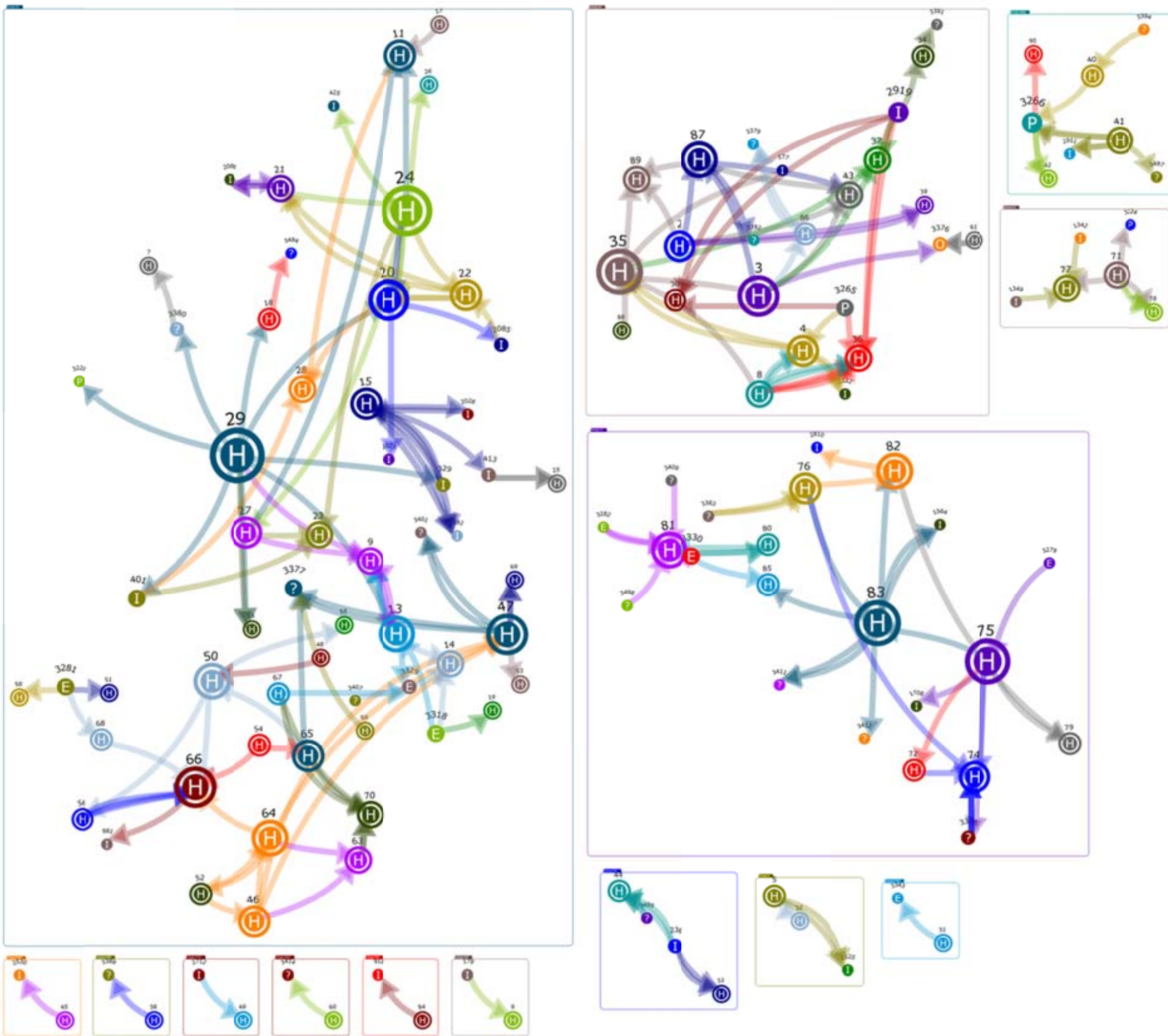

Figure 27. Household salmon networks.

Table 43. Structure and descriptive statistics of the networks presented in Figure 198.

Network	Nodes	Transactions	Communities	Households	Non- Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	59	101	8	40	11	5	3
2	24	45	1	16	4	4	0
3	22	36	6	10	3	6	3
4	8	10	2	4	2	2	0
5	6	7	3	3	3	0	0
6	4	6	1	2	1	1	0
7	3	3	2	2	1	0	0
8	2	1	1	1	0	0	1
9	2	1	2	1	1	0	0
10	2	1	2	1	0	1	0
11	2	1	1	1	1	0	0
12	2	1	1	1	0	1	0
13	2	1	2	1	1	0	0
14	2	1	1	1	1	0	0
Statistics							
Mean	10.00	15.36	2.36	6.00	2.07	1.43	0.50
Standard Error	4.25	7.57	0.56	2.86	0.76	0.55	0.29
Median	2.50	2.00	2.00	1.50	1.00	0.50	0.00
Mode	2.00	1.00	1.00	1.00	1.00	0.00	0.00
Standard Deviation	15.92	28.31	2.10	10.71	2.84	2.06	1.09
Sample Variance	253.38	801.63	4.40	114.77	8.07	4.26	1.19
Kurtosis	7.32	6.65	3.81	8.72	8.24	0.69	2.95
Skewness	2.62	2.53	2.07	2.87	2.69	1.40	2.07
Range	57.00	100.00	7.00	39.00	11.00	6.00	3.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	59.00	101.00	8.00	40.00	11.00	6.00	3.00
Sum	140.00	215.00	33.00	84.00	29.00	20.00	7.00
Count	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Confidence Level(95.0%)	9.19	16.35	1.21	6.19	1.64	1.19	0.63

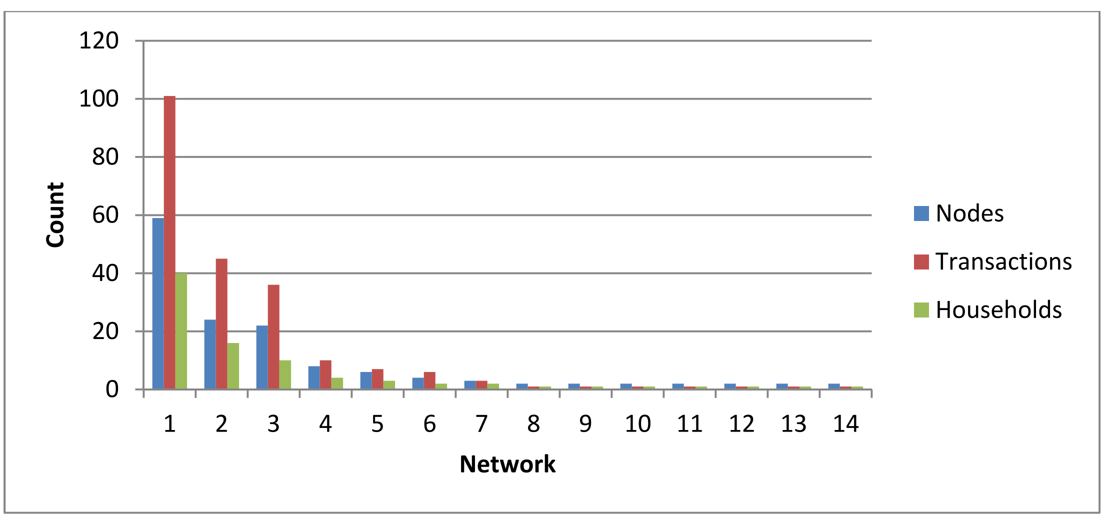

Figure 28. Significant size variation in the organization of household salmon networks.

Table 44. Correlation coefficients for the household salmon transactions in the networks.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.998	1.000					
Communities	0.834	0.810	1.000				
Households	0.993	0.993	0.791	1.000			
Non- Household nodes (P, I)	0.970	0.964	0.821	0.973	1.000		
Non- Household nodes (?, O)	0.812	0.818	0.726	0.751	0.689	1.000	
Non- Household nodes (E)	0.774	0.758	0.890	0.717	0.682	0.785	1.000

Table 45. Data and summary statistics for salmon taxa in the household networks.

Taxon	**Nodes**	**Transactions**	**Communities**	**Households**	**Non-Household nodes (P, I)**	**Non-Household nodes (?, O)**	**Non-Household nodes (E)**
Oncorhynchus nerka	108	118	14	70	9	4	6
Oncorhynchus tshawytscha	41	30	7	26	5	5	2
Oncorhynchus kisutch	35	24	6	22	1	4	0
Oncorhynchus gorbuscha	30	19	4	18	9	4	2
Oncorhynchus keta	18	12	6	12	1	2	1
Oncorhynchus sp.	16	12	5	13	21	11	0
Statistics							
Mean	41.33	35.83	7.00	26.83	7.67	5.00	1.83
Standard Error	13.90	16.68	1.46	8.90	3.04	1.26	0.91
Median	32.50	21.50	6.00	20.00	7.00	4.00	1.50
Mode	#N/A	12.00	6.00	#N/A	9.00	4.00	0.00
Standard Deviation	34.06	40.85	3.58	21.80	7.45	3.10	2.23
Sample Variance	1159.87	1668.97	12.80	475.37	55.47	9.60	4.97
Kurtosis	4.41	5.39	4.43	4.79	1.85	4.23	2.96
Skewness	2.02	2.29	2.00	2.13	1.28	1.88	1.61
Range	92.00	106.00	10.00	58.00	20.00	9.00	6.00
Minimum	16.00	12.00	4.00	12.00	1.00	2.00	0.00
Maximum	108.00	118.00	14.00	70.00	21.00	11.00	6.00
Sum	248.00	215.00	42.00	161.00	46.00	30.00	11.00
Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Confidence Level(95.0%)	35.74	42.87	3.75	22.88	7.82	3.25	2.34

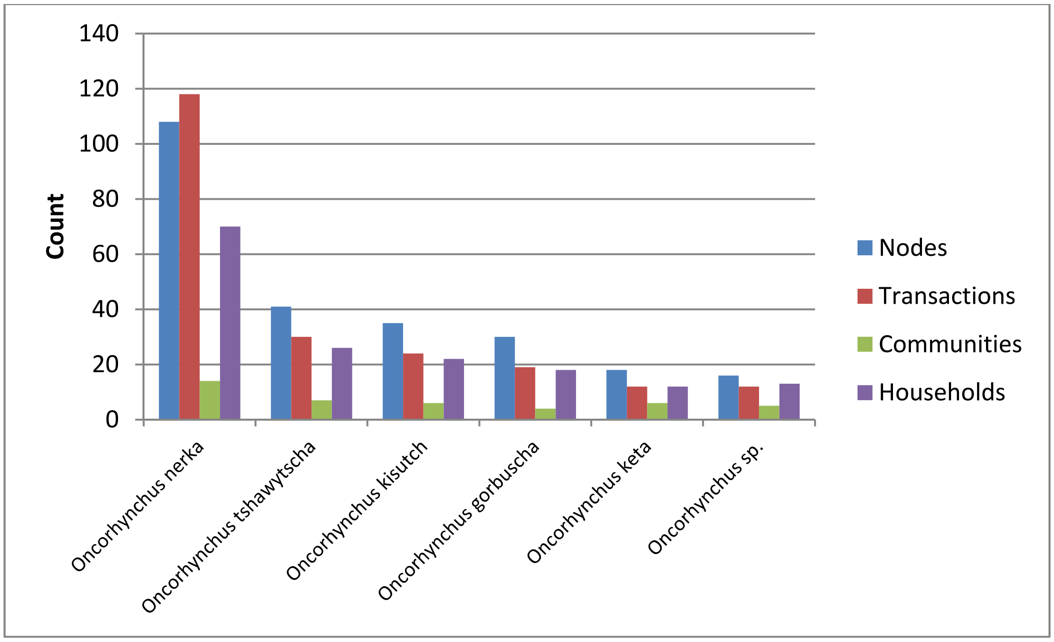

Figure 29. Graph showing the exponential decay in transactions involving different species of salmon.

Table 46. The top 20 household providers of salmon in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
29	1	9	10	10	0	-10
24	1	8	10	9	1	-8
8	2	3	8	8	0	-8
47	1	6	10	7	3	-4
83	3	7	9	7	2	-5
13	1	5	9	6	3	-3
75	3	7	7	6	1	-5
3	2	6	6	6	0	-6
2919	2	4	6	6	0	-6
15	1	4	8	5	3	-2
2	2	4	5	5	0	-5
71	5	3	5	5	0	-5
41	4	3	5	5	0	-5
82	3	5	6	4	4	0
4	2	4	7	4	3	-1
64	1	5	6	4	2	-2
87	2	5	6	4	2	-2
22	1	4	6	4	2	-2
46	1	4	5	4	1	-3
3378	3	2	5	4	1	-3
INDEX OF RETURN (mean)						-4.25

Table 47. The top 20 household receivers of salmon in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
36	2	3	8	0	8	8
66	1	6	8	1	7	6
74	3	4	7	0	7	7
20	1	6	9	3	6	3
35	2	7	8	2	6	4
9	1	3	7	1	6	5
81	3	5	6	0	6	6
70	1	3	5	0	5	5
82	3	5	6	4	4	0
3377	1	3	4	0	4	4
43	2	3	4	0	4	4
44	6	2	4	0	4	4
47	1	6	10	7	3	-4
13	1	5	9	6	3	-3
15	1	4	8	5	3	-2
4	2	4	7	4	3	-1
3266	4	4	6	3	3	0
21	1	3	6	3	3	0
11	1	4	4	1	3	2
28	1	3	3	0	3	3
INDEX OF RETURN (mean)						2.55

Household Marine Fish Networks

Turning to marine fish, there is one large network, to medium networks, and seven networks of a single household and attached individual (Figure 30, Table 48). In the largest network there are three primary providers, and a large number of smaller-scale participants. In the third network, the node labeled (E) is a cannery, which plays an important role in access to cod for some families and is central to that network. There is considerable variance in the network statistics and the dominance of the largest network is clear in Figure 31. The correlation coefficients for all categories of data are high ($r > .91$) indicating that both the expected relationships are present between nodes, transactions, and households, but also significant are non-household categories such as individuals, social groups, and commercial entities, which is different than the salmon statistics (Table 49).

The species / taxa distribution is much the same as it was in the individual networks (Table 50, Figure 32), with halibut the most important fish, followed closely by cod. Other species play only a minor role. Halibut networks are the focus of many household transactions. Cod, on the other hand, is a product of both household production and purchases made at the canneries.

It is clear from these data that there are large, integrated networks for both halibut and cod, and the levels of integration (birds nest style) are such that they might be resilient to the loss of individual providers. Cod might be more vulnerable simply because so many households are dependent on the canneries for access.

Looking at the top 20 household providers and receivers of marine fish in the region, return index numbers again are different from the combined species averages. Here the providers are still negative (RI = -4.55), indicating that the top 20 providers have an average of 4.55 more transactions going out than coming in (Table 51). On the other hand, the top 20 receivers are much closer to zero (RI= 1.95), with only two more transactions coming in than going out (Table 52). This indicates that more households are producing marine fish, and thus giving more away. This is another measure of stability because more households have primary access, either through direct harvests or direct access to processed fish.

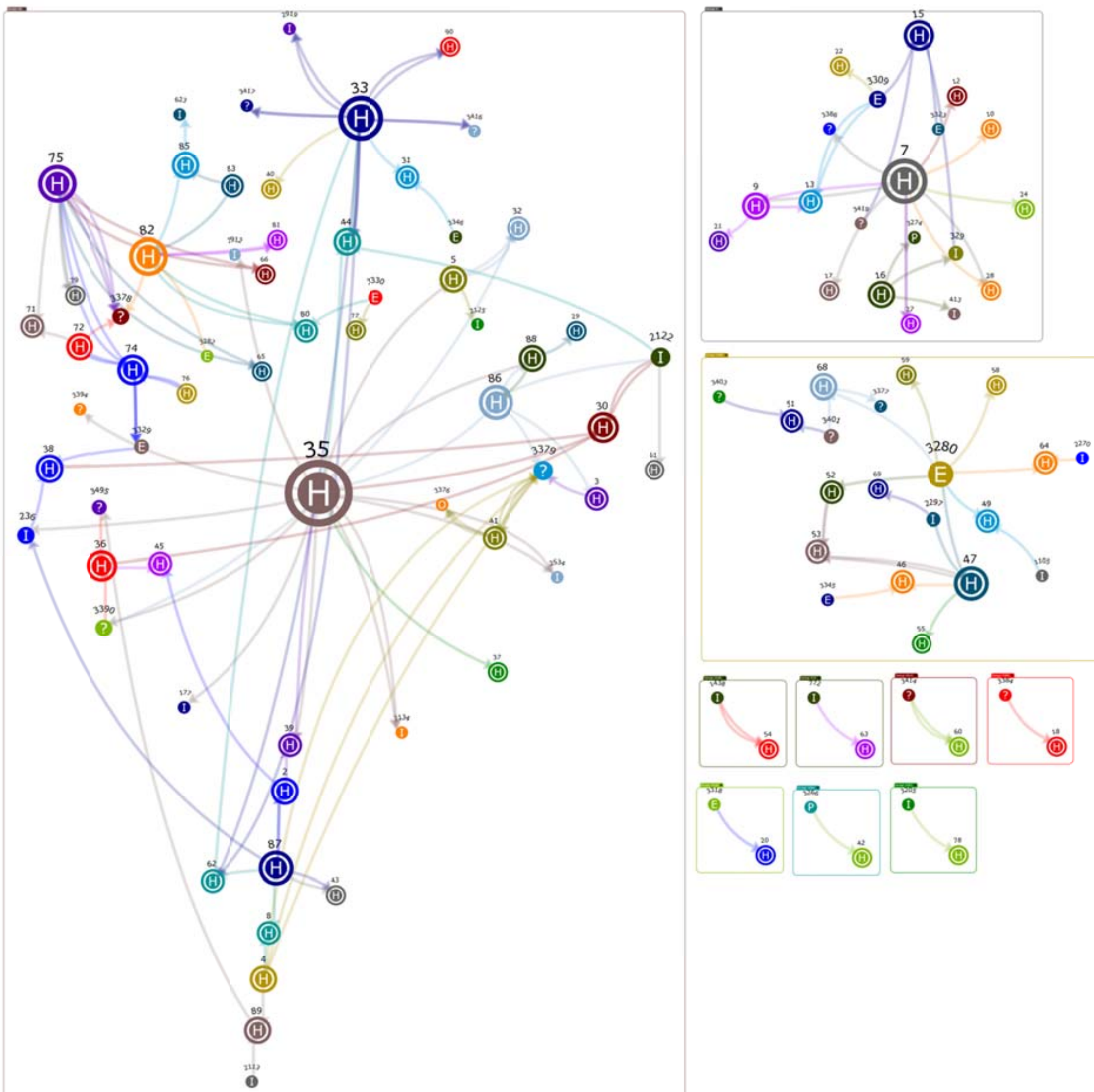

Figure 30. Household marine fish networks.

Table 48. Structure and descriptive statistics of the household marine fish networks presented in Figure 153.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non- Household nodes (E)
1	63	110	8	41	10	8	4
2	20	23	4	13	3	2	2
3	20	22	4	12	3	3	2
4	2	2	2	1	1	0	0
5	2	1	1	1	1	0	0
6	2	2	1	1	0	1	0
7	2	1	2	1	0	1	0
8	2	1	2	1	0	0	1
9	2	1	1	1	1	0	0
10	2	1	1	1	1	0	0
Statistics							
Mean	11.70	16.40	2.60	7.30	2.00	1.50	0.90
Standard Error	6.17	10.77	0.70	4.04	0.95	0.79	0.43
Median	2.00	1.50	2.00	1.00	1.00	0.50	0.00
Mode	2.00	1.00	1.00	1.00	1.00	0.00	0.00
Standard Deviation	19.52	34.05	2.22	12.77	3.02	2.51	1.37
Sample Variance	380.90	1159.60	4.93	163.12	9.11	6.28	1.88
Kurtosis	6.19	8.18	3.59	6.34	6.57	5.72	1.80
Skewness	2.42	2.80	1.85	2.45	2.45	2.30	1.52
Range	61.00	109.00	7.00	40.00	10.00	8.00	4.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	63.00	110.00	8.00	41.00	10.00	8.00	4.00
Sum	117.00	164.00	26.00	73.00	20.00	15.00	9.00
Count	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Confidence Level(95.0%)	13.96	24.36	1.59	9.14	2.16	1.79	0.98

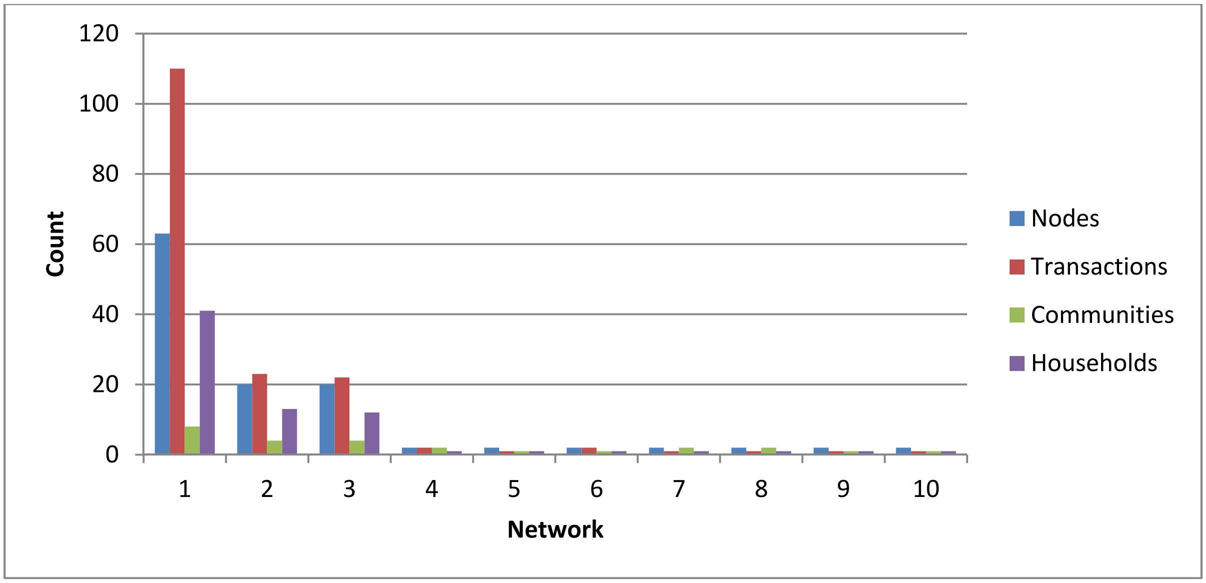

Figure 31. Graph showing the exponential decay in household marine fish network size.

Table 49. Correlation coefficients for household networks of marine fish transactions.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.991	1.000					
Communities	0.974	0.950	1.000				
Households	1.000	0.992	0.972	1.000			
Non- Household nodes (P, I)	0.988	0.986	0.945	0.989	1.000		
Non- Household nodes (?, O)	0.983	0.975	0.958	0.981	0.955	1.000	
Non- Household nodes (E)	0.950	0.913	0.971	0.948	0.913	0.922	1.000

Table 50. Data and summary statistics for taxa of marine fish in the household transaction networks.

Taxon	**Nodes**	**Transactions**	**Communities**	**Households**	**Non-Household nodes (P, I)**	**Non-Household nodes (?, O)**	**Non-Household nodes (E)**
Hippoglossus stenolepsis	94	92	13	60	0	1	7
Gadus macroephalus	69	56	9	48	0	0	4
Thaleichthys pacificus	10	6	4	6	0	0	1
Ophiodon elongatus	5	4	2	4	8	9	1
Sebastes sp.	8	4	3	4	2	3	1
Sebastes melanops	2	1	1	2	0	1	0
Clupea pallasii	2	1	1	1	16	11	0
Statistics							
Mean	27.14	23.43	4.71	17.86	3.71	3.57	2.00
Standard Error	14.34	13.65	1.73	9.44	2.33	1.72	0.98
Median	8.00	4.00	3.00	4.00	0.00	1.00	1.00

Mode	2.00	4.00	1.00	4.00	0.00	1.00	1.00
Standard Deviation	37.94	36.12	4.57	24.98	6.16	4.54	2.58
Sample Variance	1439.48	1304.62	20.90	624.14	37.90	20.62	6.67
Kurtosis	0.07	1.21	0.47	-0.35	2.36	-0.65	1.70
Skewness	1.36	1.56	1.27	1.29	1.72	1.11	1.55
Range	92.00	91.00	12.00	59.00	16.00	11.00	7.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	94.00	92.00	13.00	60.00	16.00	11.00	7.00
Sum	190.00	164.00	33.00	125.00	26.00	25.00	14.00
Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Confidence Level(95.0%)	35.09	33.40	4.23	23.11	5.69	4.20	2.39

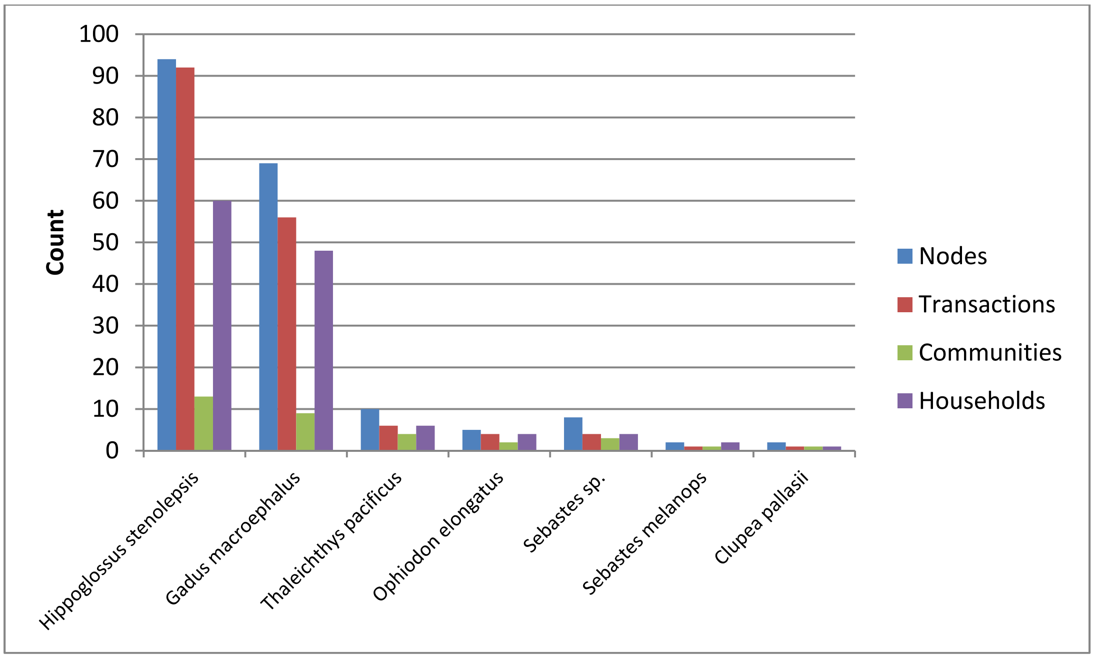

Figure 32. Chart showing the dominance of cod and halibut in the regional household transaction networks.

Table 51. The top 20 household providers of marine fish in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
35	1	14	17	17	0	-17
33	1	8	16	15	1	-14
75	1	6	12	12	0	-12
7	2	8	11	11	0	-11
3280	3	7	7	7	0	-7
87	1	5	7	7	0	-7
82	1	6	8	6	2	-4
2122	1	4	5	5	0	-5
4	1	3	5	5	0	-5
47	3	5	6	4	2	-2
3309	2	3	4	4	0	-4
72	1	3	4	4	0	-4
86	1	5	6	3	3	0
74	1	4	9	3	6	3

16	2	3	3	3	0	-3
5	1	3	4	3	1	-2
41	1	2	5	3	2	-1
3379	1	4	8	2	6	4
36	1	4	4	2	2	0
88	1	3	4	2	2	0
INDEX OF RETURN (mean)						-4.55

Table 52. The top 20 household receivers of marine fish in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
74	1	4	9	3	6	3
3379	1	4	8	2	6	4
30	1	4	5	0	5	5
44	1	3	5	0	5	5
3378	1	3	5	0	5	5
15	2	4	4	0	4	4
53	3	2	4	0	4	4
86	1	5	6	3	3	0
62	1	2	4	1	3	2
3329	1	2	4	1	3	2
39	1	2	3	0	3	3
13	2	2	3	0	3	3
32	1	2	3	0	3	3
80	1	2	3	0	3	3
82	1	6	8	6	2	-4
47	3	5	6	4	2	-2
41	1	2	5	3	2	-1
36	1	4	4	2	2	0
88	1	3	4	2	2	0
2	1	3	4	2	2	0
INDEX OF RETURN (mean)						1.95

Household Marine Mammal Networks

Marine mammals are important to a number of household distribution networks. There is one very large network, one medium sized network, and five small networks (Figure 33, Table 53). The largest network is dominated by three providers, two of which were part of the household surveys, one who was not, although he is a resident of the community. The largest network has more than 70 percent of all sea mammal transactions recorded on the project and more than 60 percent of the households in the survey. The meat went to four communities. The second sea mammal distribution network is more linear and less well integrated. There are about the same number of nodes and transactions indicating less interdependence. The second network actually includes more communities, which is surprising given the small size. Figure 33 shows clearly that there is only one large sea mammal transaction network in the region, and given the few numbers of hunters, there is probably little room for another.

All of these networks have nodes labeled (E) or (?). This is interesting here, and these stand out from the salmon and marine fish networks because in this case, these designations mean “everyone in Akutan” or “all family in Chignik” listed as receivers. Sea mammal meat is one of the most widely redistributed goods, and for this commodity, household and family lines break down and are replaced by community institutions where everyone in the village gets a share.

There is considerable variance in the network statistics and the dominance of the largest network is clear in Figure 34. The correlation coefficients for all categories of data are high (r > .98) between transactions and nodes, but considerably smaller in all other data than they were in the fish statistics (Table 54). Communities are poorly correlated in these data as the majority of transactions occur in a single community. The high correlation (r =. 965) between transactions and non-household nodes (?,O) is a product of meat being redistributed at the community level. The low values for non-household nodes (P,I) is because a single hunter who was not surveyed but who is very active in the network is a key provider, skewing the correlation.

As we discussed in the individual networks, Steller sea lions and small seals are the most important sea mammal transactions in the region (Table 55, Figure 35). All Steller sea lion transactions occur in a single community while phocid seals and most other species are distributed to multiple communities.

Tables 56 and 57 show the top 20 providers and the top 20 receivers of sea mammal meat. These data are somewhat less significant because there are a small number of providers, and the top 10 might have been a better presentation. These data indicate that there are really only three top providers in the entire region and, even though the values are close to zero, with RI = -2.7 for providers, and RI= 1.65 for receivers, the disparity is actually quite great because the number of hunters is so small. In fact, because of the few numbers of household sea mammal transactions, there are many hunters / receivers on both lists.

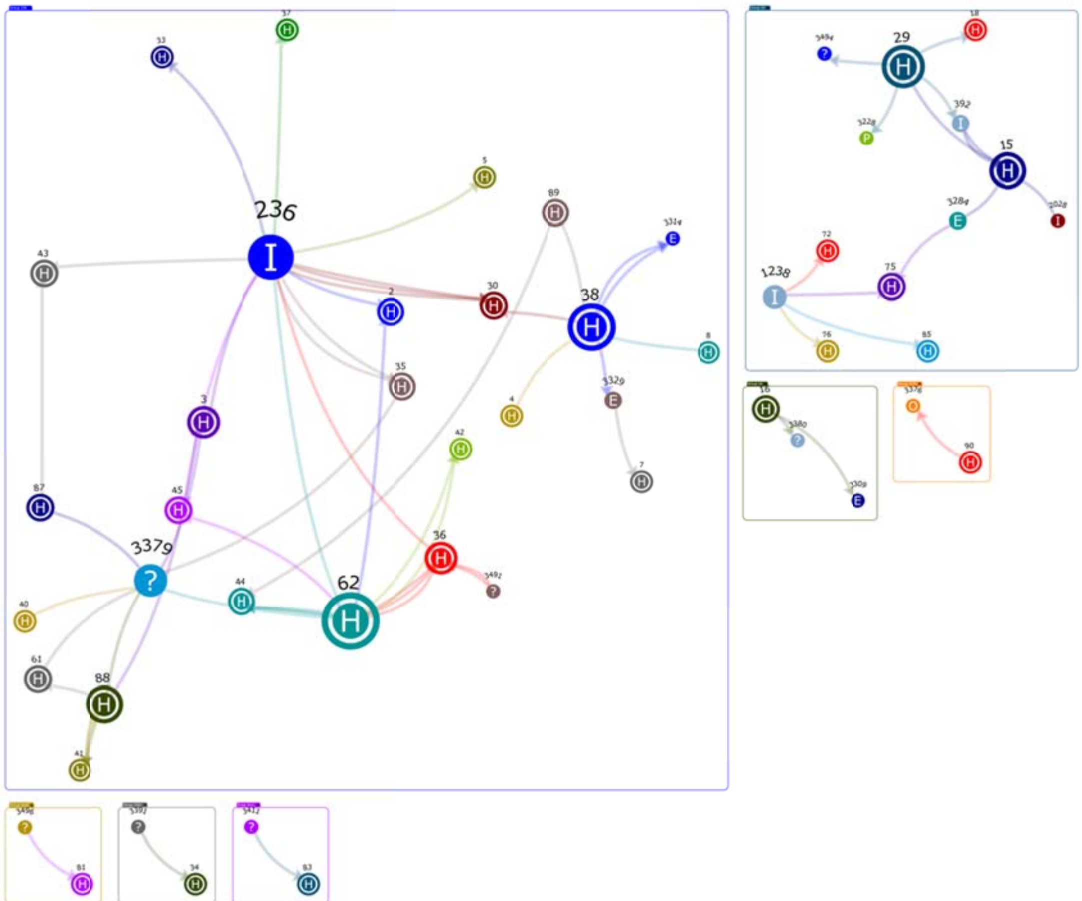

Figure 33. Sea mammal networks for households in the region.

Table 53. Structure and descriptive statistics of the household sea mammal networks presented in Figure 204.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	28	50	4	23	1	2	2
2	13	14	5	7	4	1	1
3	3	2	2	1	0	1	1
4	2	1	1	1	0	1	0
5	2	1	1	1	0	1	0
6	2	1	1	1	0	1	0
7	2	1	2	1	0	1	0
Statistics							
Mean	7.43	10.00	2.29	5.00	0.71	1.14	0.57
Standard Error	3.75	6.91	0.61	3.12	0.57	0.14	0.30
Median	2.00	1.00	2.00	1.00	0.00	1.00	0.00
Mode	2.00	1.00	1.00	1.00	0.00	1.00	0.00
Standard Deviation	9.93	18.28	1.60	8.25	1.50	0.38	0.79
Sample Variance	98.62	334.00	2.57	68.00	2.24	0.14	0.62
Kurtosis	3.42	5.44	-0.38	5.33	5.58	7.00	0.27
Skewness	1.94	2.32	1.05	2.30	2.35	2.65	1.11
Range	26.00	49.00	4.00	22.00	4.00	1.00	2.00
Minimum	2.00	1.00	1.00	1.00	0.00	1.00	0.00
Maximum	28.00	50.00	5.00	23.00	4.00	2.00	2.00
Sum	52.00	70.00	16.00	35.00	5.00	8.00	4.00
Count	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Confidence Level(95.0%)	9.18	16.90	1.48	7.63	1.38	0.35	0.73

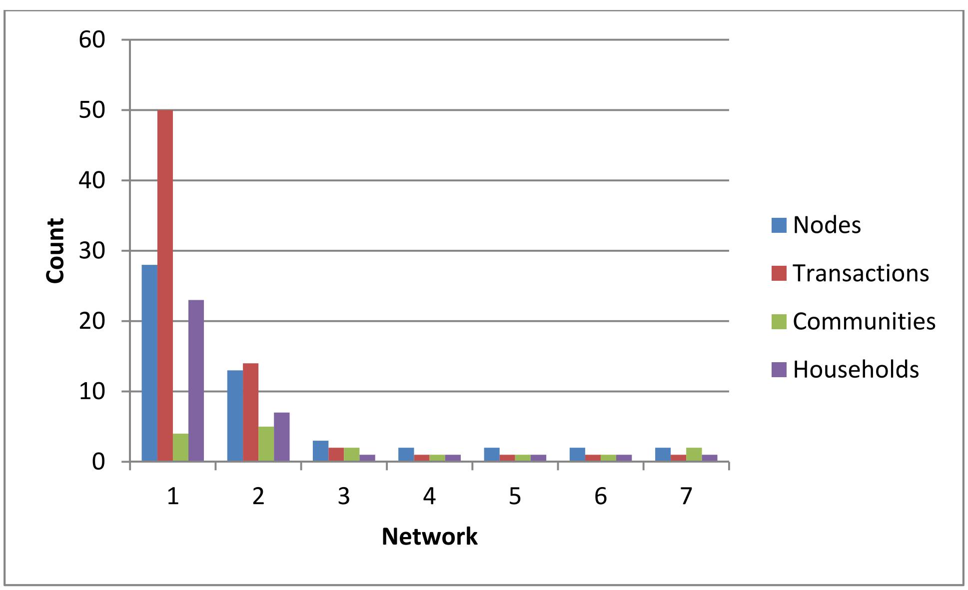

Figure 34. Network dominance of a large distribution network of sea mammals.

Table 54. Correlation coefficients for sea mammal networks.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.988	1.000					
Communities	0.776	0.677	1.000				
Households	0.989	1.000	0.681	1.000			
Non- Household nodes (P, I)	0.481	0.341	0.873	0.351	1.000		
Non- Household nodes (?, O)	0.913	0.965	0.471	0.963	0.084	1.000	
Non- Household nodes (E)	0.902	0.881	0.774	0.873	0.445	0.801	1.000

Table 55. Data and summary statistics for taxa of marine mammals in the household transaction networks.

Taxon	**Nodes**	**Transactions**	**Communities**	**Households**	**Non-Household nodes (P, I)**	**Non-Household nodes (?, O)**	**Non- Household nodes (E)**
Eumetopias jubatus	24	24	1	20	1	2	1
Phoca vitulina	31	23	6	19	1	0	3
Callorhinus ursinus	8	6	2	5	4	5	0
family Phocidae	10	6	1	9	1	2	0
suborder Pinniped	10	5	3	8	0	1	0
order Large Cetacea	4	2	4	2	0	1	1
Balaena mysticetus	3	2	2	2	2	0	1
Enhydra lutris	2	1	1	1	2	0	0
Odobenus rosmarus divergens	2	1	2	1	0	0	0
Statistics							
Mean	10.44	7.78	2.44	7.44	1.11	1.22	0.67
Standard Error	3.44	3.04	0.56	2.48	0.42	0.55	0.33
Median	8.00	5.00	2.00	5.00	1.00	1.00	0.00
Mode	2.00	6.00	2.00	1.00	1.00	0.00	0.00
Standard Deviation	10.32	9.13	1.67	7.43	1.27	1.64	1.00
Sample Variance	106.53	83.44	2.78	55.28	1.61	2.69	1.00
Kurtosis	0.79	0.41	1.64	-0.37	3.15	3.30	3.64
Skewness	1.36	1.42	1.37	1.04	1.63	1.73	1.82
Range	29.00	23.00	5.00	19.00	4.00	5.00	3.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	31.00	24.00	6.00	20.00	4.00	5.00	3.00
Sum	94.00	70.00	22.00	67.00	10.00	11.00	6.00
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Confidence Level(95.0%)	7.93	7.02	1.28	5.71	0.98	1.26	0.77

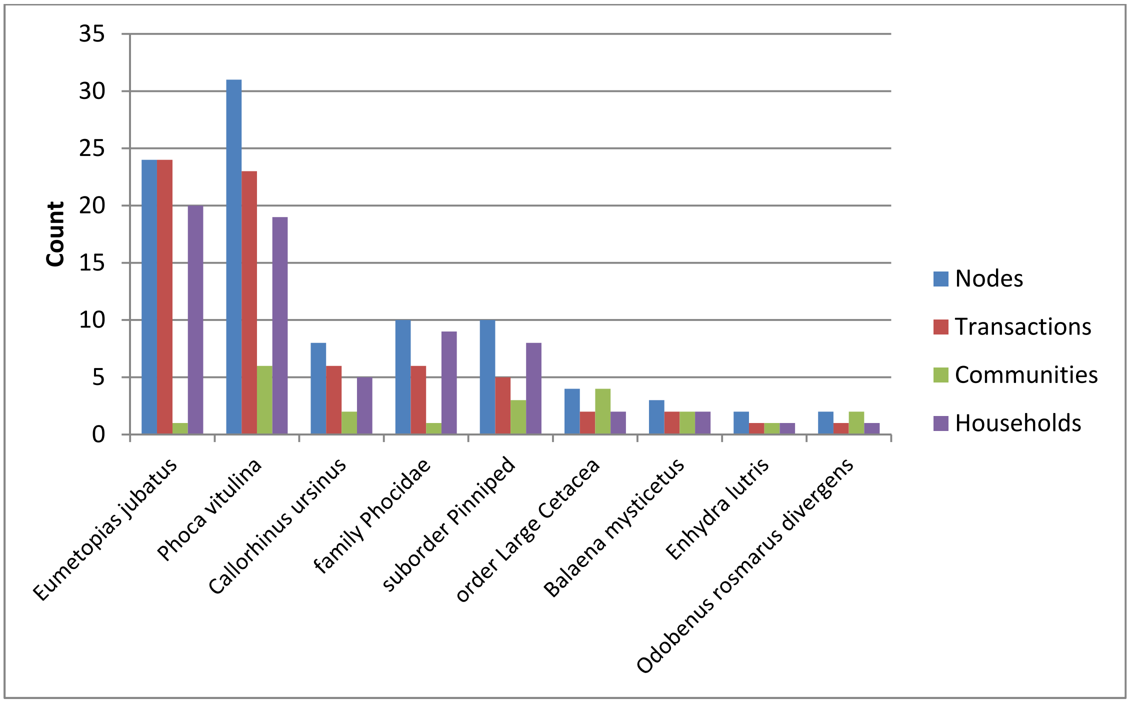

Figure 35. Networks of sea mammal distribution from households.

Table 56. The top 20 household providers of marine mammals in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
236	1	11	14	14	0	-14
62	1	8	14	13	3	-10
88	1	4	7	7	0	-7
29	2	5	5	5	0	-5
38	1	6	7	4	3	-1
1238	2	4	4	4	0	-4
87	1	2	2	2	0	-2
3284	2	2	2	2	0	-2
16	3	2	2	2	0	-2
392	2	2	3	2	1	-1
89	1	2	2	2	0	-2
3491	1	1	2	2	0	-2
3	1	3	3	1	2	1
61	1	2	2	1	1	0
35	1	2	3	1	2	1
3329	1	2	2	1	1	0
3391	6	1	1	1	0	-1
4	1	1	1	1	0	-1
3496	5	1	1	1	0	-1
2028	2	1	1	1	0	-1
INDEX OF RETURN (mean)						-2.7

Table 57. The top 20 household receivers of marine mammals in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
3379	1	7	7	0	7	7
36	1	3	6	0	6	6
15	2	4	5	0	5	5
30	1	2	4	0	4	4
44	1	2	4	0	4	4
41	1	1	4	0	4	4
62	1	8	14	13	3	-10
38	1	6	7	4	3	-1
3	1	3	3	1	2	1
35	1	2	3	1	2	1
45	1	2	2	0	2	2
2	1	2	2	0	2	2
43	1	2	2	0	2	2
75	2	2	2	0	2	2
42	1	1	2	0	2	2
3314	1	1	2	0	2	2
392	2	2	3	2	1	-1
61	1	2	2	1	1	0
3329	1	2	2	1	1	0
5	1	1	1	0	1	1
INDEX OF RETURN (mean)						1.65

Household Terrestrial Mammal Networks

The household terrestrial networks (Figure 36) are almost identical to the individual terrestrial mammal networks for two key reasons. First, the largest network is solely created around the actions of one individual that gives beef to a large number of households. The second network is structured around sport hunters who redistribute moose meet to villages after hunting. The result is that both of these star pattern networks are highly vulnerable, and structure around the activities of a single key node. They have little resilience or sustainability and the loss of the key node, either the individual in network 1, or sport hunting in network 2, would be a disaster. This can be seen especially in the second network where there are 12 nodes and 11 transactions – everyone is connected only once, and all to the same provider (Table 58).

The third network is also interesting but for quite different reasons (Figure 36 middle right). This is a caribou distribution network that involves hunters from four communities and where caribou meat is redistributed to 16 households. It is a strong cluster pattern network because the loss of any one node would have little impact on the overall structure and integrity of the network.

The very large number of small networks is also interesting in that terrestrial game is given between small groups. Figure 37 shows the logarithmic falloff in network size as measured but nodes and transactions. We find in Table 59 that for the first time, the correlation coefficients are very low, likely a product of the star pattern networks that dominate. These patterns are attributed to the fundamental differences between networks that are dictated and managed by outsiders with control over a single resources and its distribution, and a local historical network of family relations where many individuals have primary access.

As shown before, cattle, moose, and caribou are the three primary species, making up over 96 percent of the transactions. The numbers of nodes, transactions, and households are nearly identical for all three taxa, but caribou are much more widely distributed between communities (Table 60, Figure 38).

Because of the small number of providers and receivers in these networks, we computed the average RI for only the top ten of each category (Tables 61 and 62). Here we find a considerable differential between the top ten providers with an average RI of -6.6, and the receivers, with an average RI of 2.8. If one household with four transactions in and four transactions out, which occurs on both charts, were to be removed, the disparity would be much greater (-7.33 versus 3.11). Much of the overall disparity comes from one super provider household with an RI = -34.

These data indicate that the cattle and moose meat networks are highly vulnerable, while the caribou networks, if they were allowed to hunt, should be quite stable.

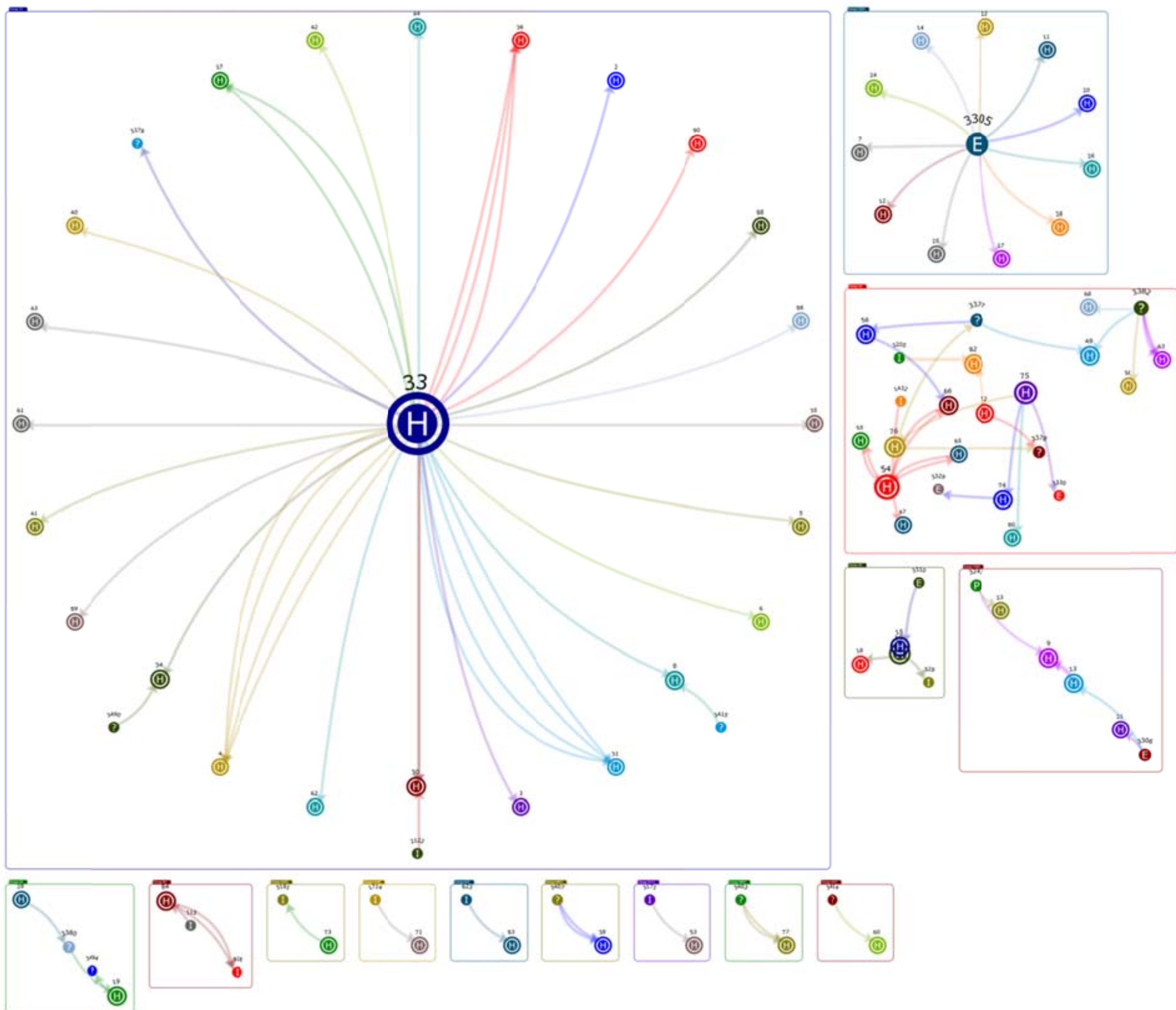

Figure 36. Terrestrial mammal networks.

Table 58. Data and statistics for the household terrestrial mammal networks.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	28	37	3	24	3	3	0
3	23	27	4	16	3	3	2
2	12	11	2	11	0	0	1
4	5	7	1	3	0	0	1
5	6	6	2	4	0	0	1
6	4	3	1	2	2	2	0
7	3	3	2	1	0	0	0
11	2	2	2	1	1	1	0
13	2	2	2	1	1	1	0
8	2	1	2	1	0	0	0
9	2	1	1	1	0	0	0
10	2	1	1	1	0	0	0
12	2	1	2	1	0	0	0
14	2	1	1	1	1	1	0
Statistics							
Mean	6.79	7.36	1.86	4.86	0.79	0.79	0.36
Standard Error	2.26	2.94	0.23	1.90	0.30	0.30	0.17
Median	2.50	2.50	2.00	1.00	0.00	0.00	0.00
Mode	2.00	1.00	2.00	1.00	0.00	0.00	0.00
Standard Deviation	8.44	11.01	0.86	7.12	1.12	1.12	0.63
Sample Variance	71.26	121.32	0.75	50.75	1.26	1.26	0.40
Kurtosis	2.82	3.91	1.75	3.43	0.28	0.28	2.21
Skewness	1.95	2.14	1.14	2.02	1.25	1.25	1.69
Range	26.00	36.00	3.00	23.00	3.00	3.00	2.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	28.00	37.00	4.00	24.00	3.00	3.00	2.00
Sum	95.00	103.00	26.00	68.00	11.00	11.00	5.00
Count	14.00	14.00	14.00	14.00	14.00	14.00	14.00
Confidence Level(95.0%)	4.87	6.36	0.50	4.11	0.65	0.65	0.37

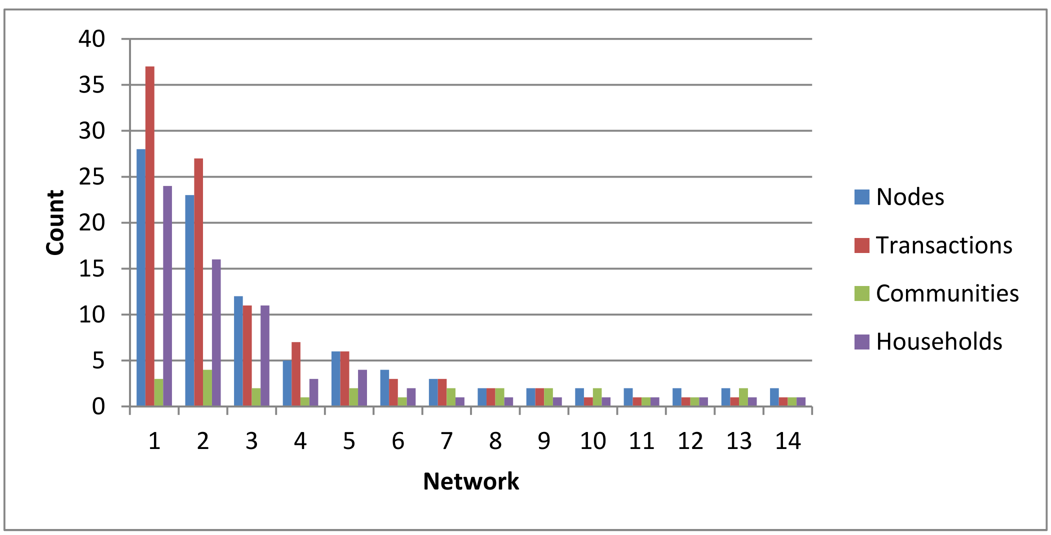

Figure 37. Network distribution for the household terrestrial mammal networks.

Table 59. Correlation coefficients for the household terrestrial mammal networks.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.993	1.000					
Communities	0.765	0.749	1.000				
Households	0.991	0.984	0.721	1.000			
Non- Household nodes (P, I)	0.750	0.760	0.601	0.708	1.000		
Non- Household nodes (?, O)	0.750	0.760	0.601	0.708	1.000	1.000	
Non- Household nodes (E)	0.505	0.454	0.522	0.438	0.224	0.224	1.000

Table 60. Taxa in the household terrestrial mammal network.

Taxon	**Nodes**	**Transactions**	**Communities**	**Households**	**Non- Household nodes (P, I)**	**Non- Household nodes (?, O)**	**Non- Household nodes (E)**
Bos sp.	34	39	3	28	0	3	1
Alces alces	37	33	9	27	7	5	2
Rangifer tarandus	35	28	8	21	3	5	2
Erethizon dorsatum	2	1	1	1	0	1	0
Bison bison	2	1	2	1	0	1	0
Lepus othus	2	1	2	1	2	1	0
Statistics							
Mean	18.67	17.17	4.17	13.17	2.00	2.67	0.83
Standard Error	7.46	7.37	1.40	5.53	1.13	0.80	0.40
Median	18.00	14.50	2.50	11.00	1.00	2.00	0.50
Mode	2.00	1.00	2.00	1.00	0.00	1.00	0.00
Standard Deviation	18.28	18.05	3.43	13.54	2.76	1.97	0.98
Sample Variance	334.27	325.77	11.77	183.37	7.60	3.87	0.97
Kurtosis	-3.30	-2.89	-1.66	-3.03	1.92	-2.39	-2.39
Skewness	0.01	0.15	0.86	0.12	1.46	0.46	0.46
Range	35.00	38.00	8.00	27.00	7.00	4.00	2.00
Minimum	2.00	1.00	1.00	1.00	0.00	1.00	0.00
Maximum	37.00	39.00	9.00	28.00	7.00	5.00	2.00
Sum	112.00	103.00	25.00	79.00	12.00	16.00	5.00
Count	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Confidence Level(95.0%)	19.19	18.94	3.60	14.21	2.89	2.06	1.03

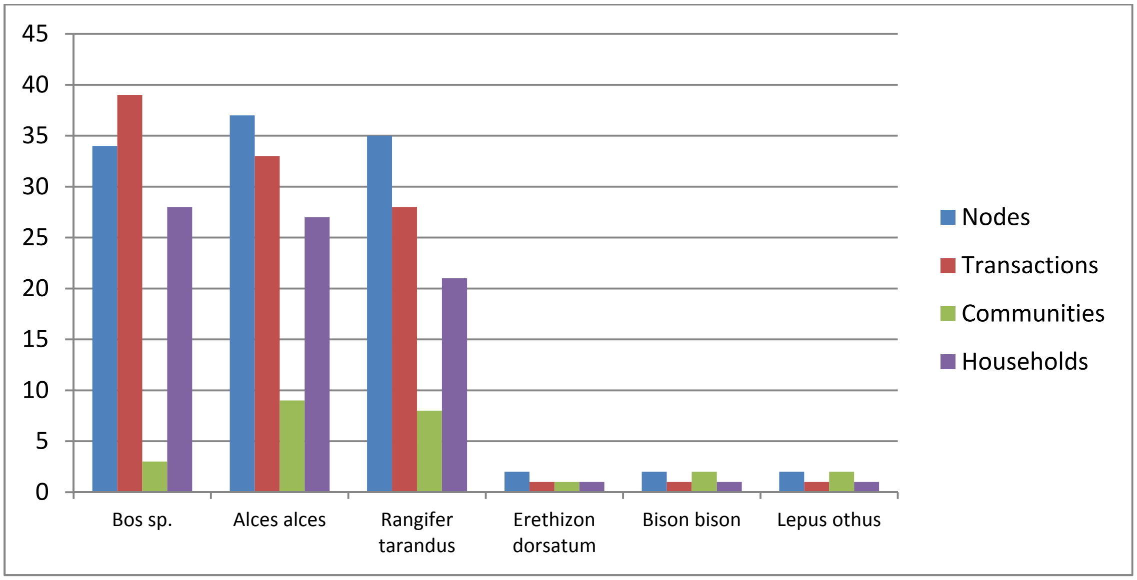

Figure 38. Network distribution for taxa in the terrestrial mammal networks.

Table 61. The top 10 household providers of terrestrial mammals in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
33	1	24	34	34	0	-34
3305	2	11	11	11	0	-11
3382	3	4	6	6	0	-6
16	4	3	6	6	0	-6
54	3	5	8	4	4	0
75	3	4	4	4	0	-4
76	3	3	3	2	1	-1
3377	3	3	3	2	1	-1
3306	5	2	2	2	0	-2
13	5	2	3	2	1	-1
INDEX OF RETURN (mean)						-6.6

Table 62. The top 10 household receivers of terrestrial mammals in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
15	4	2	5	0	5	5
54	3	5	8	4	4	0
31	1	1	4	0	4	4
4	1	1	4	0	4	4
30	1	2	3	0	3	3
9	5	2	3	0	3	3
36	1	1	3	0	3	3
63	3	1	3	0	3	3
66	3	2	3	1	2	1
82	3	2	2	0	2	2
INDEX OF RETURN (mean)						2.8

Household Bird and Egg Networks

Household bird and egg distribution networks are interesting. Of the 24 transaction networks in the study area, the largest networks have multiple top producers and good cross-integration (Figure 39). The system is dominated by three large networks and a large number of smaller networks, many represented by a single transaction (Table 63). All of the mean values are small for all categories emphasizing the small scale of these transactions. But the three largest include 40 households which is more than all of the other 21 networks combined, providing the exponential distribution seen in Figure 40.

The correlation coefficients are low in these data, showing the household harvesting of birds and eggs – few are leaving outside the kin groups, and most are traded within small social groupings (Table 64).

Once again, the primary species in these transactions are gull eggs and ptarmigan, followed by various ducks and geese (Table 65). There is a larger number of species and they scale downward in importance linearly, a pattern not seen in the household data presented so far (Figure 41).

The top 20 providers of eggs and birds have generally given much more than they receive (RI = -3.25) as seen in Table 66. The top 20 receivers are closer to zero (RI = 1.8), primarily because so many of the providers are also receivers (Table 67).

The larger bird networks are more stable than some other larger networks discussed above because more people can participate. A land-based hunt for birds is often done by teen boys with boats or similar equipment. Gull eggs can also be harvested by a great range of participants. Both these factors make the bird and egg networks more resilient to perturbations.

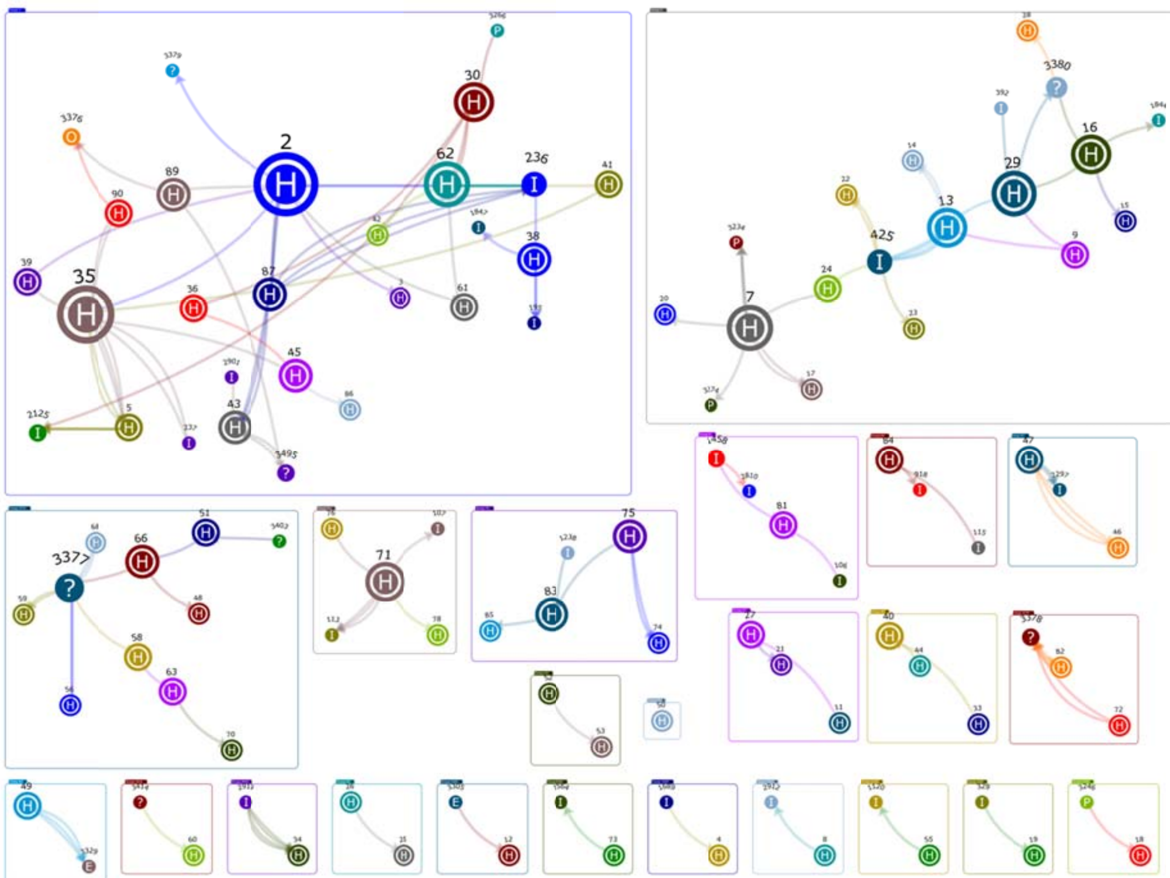

Figure 39. Bird and egg networks.

Table 63. Bird and egg network data and statistics.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	28	59	3	18	7	3	0
2	19	28	3	13	5	1	0
3	11	14	3	9	0	2	0
4	5	6	2	3	2	0	0
5	5	6	2	4	1	0	0
6	4	3	4	1	3	0	0
7	3	2	2	1	2	0	0
8	3	5	2	2	1	0	0
9	3	2	1	3	0	0	0
10	3	2	1	3	0	0	0
11	3	6	1	2	0	1	0
12	2	4	2	1	0	0	1
13	2	1	1	1	0	1	0
14	2	4	1	1	1	0	0
15	2	1	1	2	0	0	0
16	2	1	2	1	0	0	1
17	2	1	2	1	1	0	0
18	2	1	1	1	1	0	0
19	2	1	1	1	1	0	0
20	2	1	1	1	1	0	0
21	2	1	1	1	1	0	0
22	2	1	1	1	1	0	0
23	2	1	1	2	0	0	0
24	1	1	1	1	0	0	0
Statistics							
Mean	4.67	6.33	1.67	3.08	1.17	0.33	0.08
Standard Error	1.28	2.59	0.18	0.87	0.35	0.16	0.06
Median	2.00	2.00	1.00	1.00	1.00	0.00	0.00
Mode	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Standard Deviation	6.27	12.68	0.87	4.26	1.71	0.76	0.28
Sample Variance	39.28	160.67	0.75	18.17	2.93	0.58	0.08
Kurtosis	9.05	13.91	0.72	6.94	5.82	6.50	9.12
Skewness	3.01	3.60	1.18	2.68	2.33	2.56	3.22
Range	27.00	58.00	3.00	17.00	7.00	3.00	1.00
Minimum	1.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	28.00	59.00	4.00	18.00	7.00	3.00	1.00
Sum	112.00	152.00	40.00	74.00	28.00	8.00	2.00
Count	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Confidence Level(95.0%)	2.65	5.35	0.37	1.80	0.72	0.32	0.12

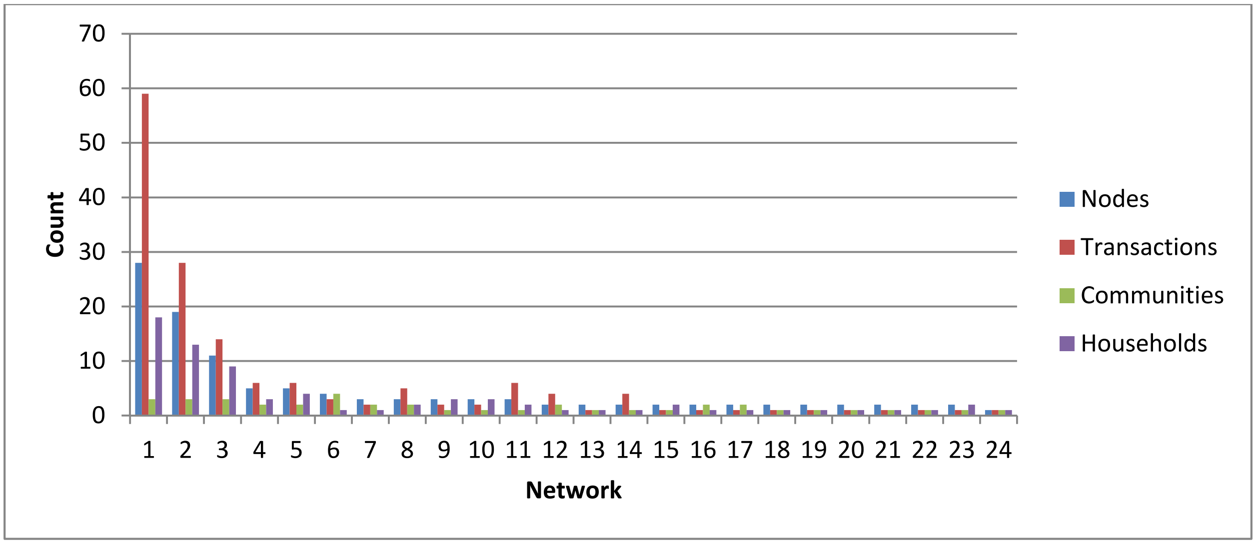

Figure 40. Plot of the bird and egg network data.

Table 64. Correlation coefficients for the bird and egg network data for households.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.979	1.000					
Communities	0.602	0.532	1.000				
Households	0.986	0.954	0.548	1.000			
Non- Household nodes (P, I)	0.853	0.845	0.624	0.767	1.000		
Non- Household nodes (?, O)	0.844	0.853	0.439	0.849	0.556	1.000	
Non- Household nodes (E)	-0.131	-0.093	0.118	-0.151	-0.210	-0.135	1.000

Table 65. Bird and egg taxa data for the household networks.

Taxon	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
Larus sp.	55	41	8	39	3	2	0
Lagopus sp.	46	28	10	30	3	0	2
Anatidae family	28	17	8	18	2	0	1
Branta bernicla	14	12	5	10	1	0	0
Chen canagica	16	9	6	11	0	0	1
Rock Duck	12	9	2	8	2	0	0
Fratercula sp.	10	7	1	7	3	1	0
Branta canadensis	13	7	5	10	10	5	0
Anas crecca	8	5	2	5	0	0	0
Melanitta sp.	6	4	2	4	12	2	0
Histrionicus histrionicus	7	4	1	4	6	3	0
Anas platyrhynchos	4	2	3	2	0	3	0
Unknown Goose	4	2	1	3	3	0	0
Bucephala clangula	2	1	1	1	3	1	0
Aythya afinis	2	1	1	2	3	0	0
Sterna sp.	2	1	1	2	0	0	0
Bufflehead	2	1	1	2	0	1	0
Grus canadensis	2	1	1	1	0	1	0
Statistics							
Mean	12.94	8.44	3.28	8.83	2.83	1.06	0.22
Standard Error	3.60	2.52	0.70	2.46	0.81	0.34	0.13
Median	7.50	4.50	2.00	4.50	2.50	0.50	0.00
Mode	2	1	1	2	3	0	0
Standard Deviation	15.29	10.69	2.97	10.46	3.42	1.43	0.55
Sample Variance	233.82	114.38	8.80	109.32	11.68	2.06	0.30
Kurtosis	3.23	4.68	-0.01	3.78	2.66	2.01	6.36
Skewness	1.95	2.15	1.13	2.03	1.70	1.51	2.57
Range	53	40	9	38	12	5	2
Minimum	2	1	1	1	0	0	0
Maximum	55	41	10	39	12	5	2
Sum	233	152	59	159	51	19	4
Count	18	18	18	18	18	18	18
Confidence Level(95.0%)	7.60	5.32	1.48	5.20	1.70	0.71	0.27

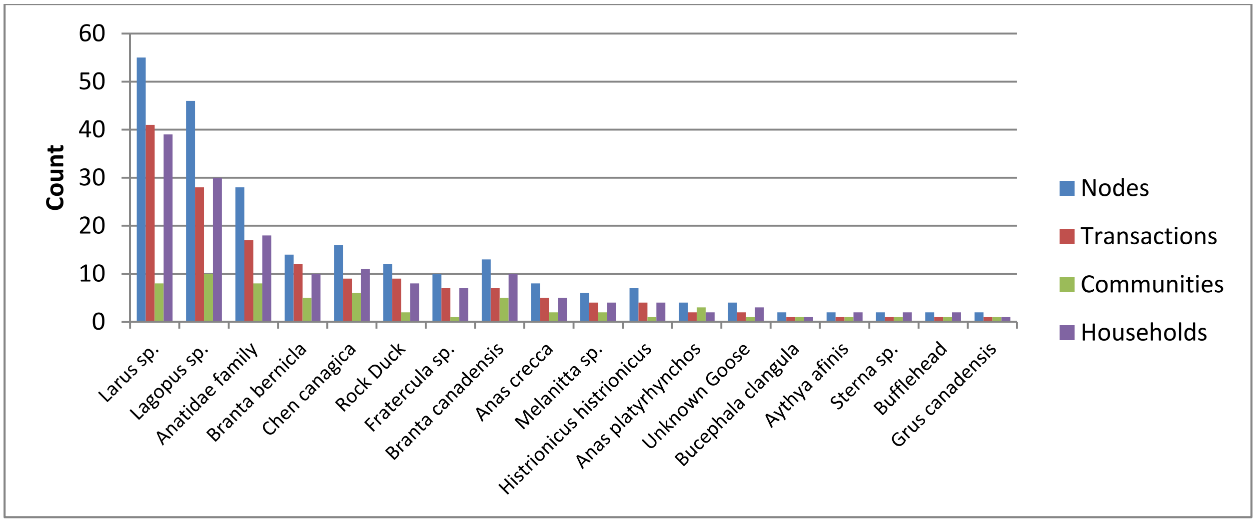

Figure 41. Taxa data for the bird and egg household networks.

Table 66. The top 20 household providers of birds and eggs in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
62	1	5	12	12	0	-12
87	1	3	9	9	0	-9
35	1	7	13	8	5	-3
7	2	5	8	8	0	-8
425	2	4	8	8	0	-8
2	1	8	11	5	6	1
71	4	4	6	5	1	-4
75	5	3	5	5	2	-3
49	12	2	5	5	2	-3
29	2	5	5	4	1	-3
5	1	2	9	4	5	1
2919	14	1	4	4	0	-4
3377	3	5	9	3	6	3
13	2	4	8	3	5	2
45	1	3	3	3	0	-3
66	3	3	3	3	0	-3
38	1	3	4	3	1	-2
90	1	2	3	3	0	-3
47	8	2	5	3	2	-1
68	3	1	3	3	0	-3
INDEX OF RETURN (mean)						-3.25

Table 67. The top 20 household receivers of birds and eggs in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
236	1	4	11	2	9	7
2	1	8	11	5	6	1
3377	3	5	9	3	6	3
43	1	3	6	0	6	6
35	1	7	13	8	5	-3
5	1	2	9	4	5	1
13	2	4	8	3	5	2
3378	11	2	6	1	5	4
2125	1	2	5	0	5	5
30	1	4	5	1	4	3
34	14	1	4	0	4	4
113	4	1	3	0	3	3
3234	2	1	3	0	3	3
3329	12	1	3	0	3	3
75	5	3	5	5	2	-3
49	12	2	5	5	2	-3
47	8	2	5	3	2	-1
16	2	4	4	2	2	0
50	24	1	2	2	2	0
83	5	3	3	1	2	1
INDEX OF RETURN (mean)						1.8

Household Shellfish Networks

The household shellfish and marine invertebrate networks, much like the individual shellfish networks, exhibit connected star and cluster patterns largely due to the fundamental differences in access between king crab, and all other shellfish taxa (Figure 42). Of the nine identified networks for the redistribution of various shellfish taxa, the first two contain 80 percent of the network nodes (Table 68). The descriptive statistics have a very high sample variance showing the skewed dominance of these two networks in the entire regional system, which is graphically displayed in Figure 43. There is a simple positive correlation (r > .93) between the numbers of nodes in these networks and all other categories of analysis (Table 69).

Even though most of the region is connected through two large networks, there are at least seven resources that contribute to these connections, the most important being octopus, king crab, and black katy chitons. Opilio crab and various categories of clam are also important but less so (Table 70). The broad use and exchange of shellfish in this region, and the importance of multiple species and taxa (Figure 44), indicate that shellfish are an important part of these villages.

As described in the individual networks, there are two sections to the largest network. There is the octopus and chiton exchange network that is a cluster type, with strong, active interconnections. This part of the network is least vulnerable to small perturbations in the system. But this is connected to star networks where, in this case, everyone gets king crab through either a processer, a store, or directly from crab boats passing through town. This part of the network is completely co-dependent on the commercial king crab fishery because the communities have been shut out of participation in that industry.

Considering the top 20 providers (RI = -4.55), and the top 20 receivers of shellfish transactions (RI = 2.3), there is considerable bias in the providers list primarily because the canneries, stores, and crab boats are considered in these transactions (Tables 71 and 72).

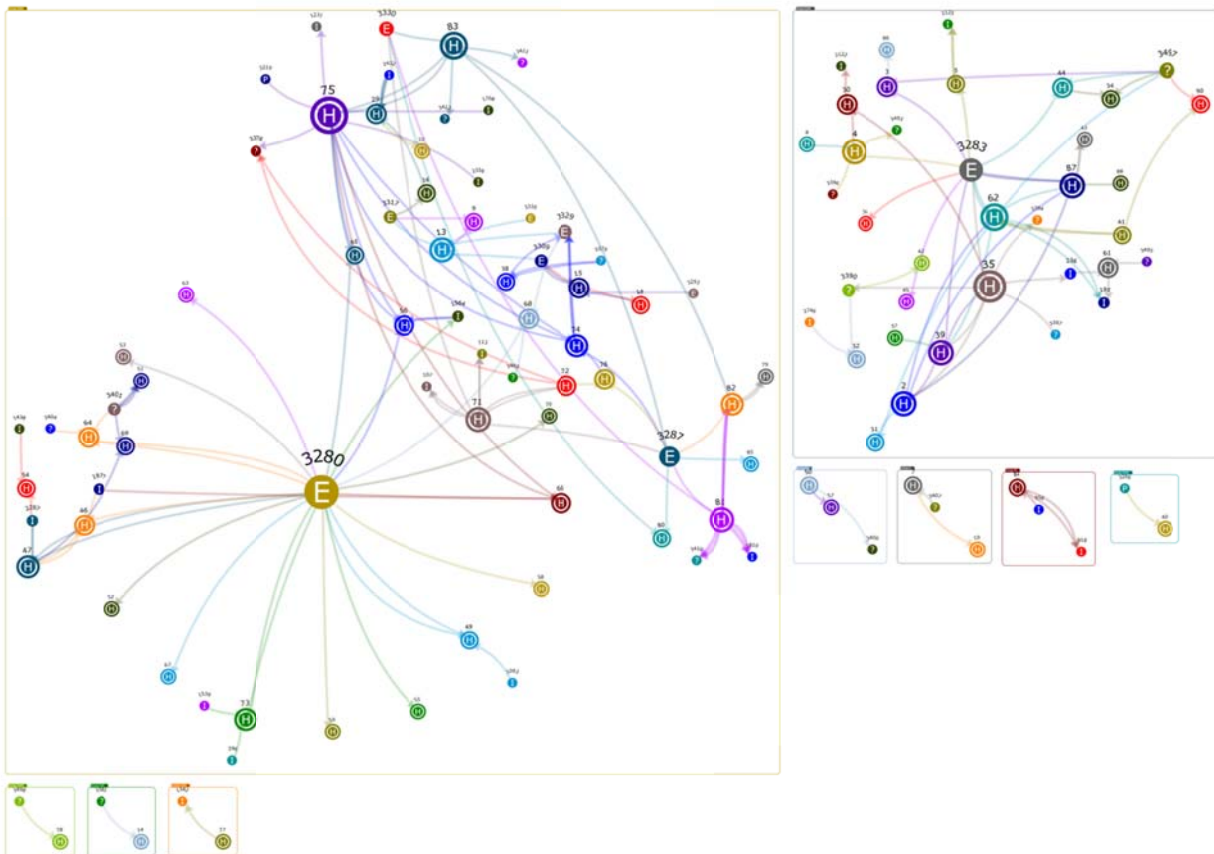

Figure 42. Shellfish networks for households.

Table 68. Shellfish household network data.

Network	Nodes	Transactions	Communities	Households	Non- Household nodes (P, I)	Non- Household nodes (?, O)	Non- Household nodes (E)
1	70	121	11	39	15	8	8
2	37	56	4	24	5	7	1
3	3	2	2	2	0	1	0
4	3	2	2	2	0	1	0
5	3	3	2	1	2	0	0
6	2	1	1	1	1	0	0
7	2	1	1	1	0	1	0
8	2	1	2	1	0	1	0
9	2	1	2	1	1	0	0
Mean	13.78	20.89	3.00	8.00	2.67	2.11	1.00
Standard Error	8.00	13.88	1.04	4.62	1.63	1.03	0.88
Median	3.00	2.00	2.00	1.00	1.00	1.00	0.00
Mode	2.00	1.00	2.00	1.00	0.00	1.00	0.00
Standard Deviation	23.99	41.64	3.12	13.85	4.90	3.10	2.65
Sample Variance	575.44	1733.86	9.75	191.75	24.00	9.61	7.00
Kurtosis	3.84	4.60	7.08	2.74	6.30	0.76	8.59
Skewness	2.10	2.22	2.60	1.92	2.46	1.55	2.92
Range	68.00	120.00	10.00	38.00	15.00	8.00	8.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	70.00	121.00	11.00	39.00	15.00	8.00	8.00
Sum	124.00	188.00	27.00	72.00	24.00	19.00	9.00
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Confidence Level(95.0%)	18.44	32.01	2.40	10.64	3.77	2.38	2.03

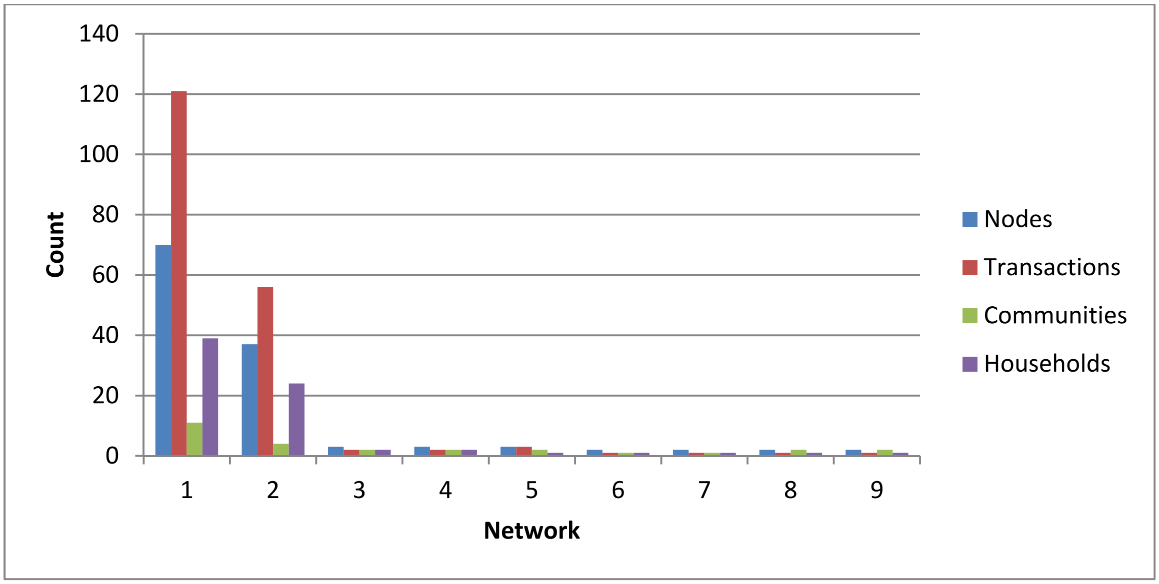

Figure 43. Household shellfish network distribution.

Table 69. Correlation coefficients for the household shellfish network data.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.999	1.000					
Communities	0.961	0.972	1.000				
Households	0.997	0.992	0.940	1.000			
Non- Household nodes (P, I)	0.973	0.981	0.981	0.953	1.000		
Non- Household nodes (?, O)	0.953	0.938	0.852	0.973	0.859	1.000	
Non- Household nodes (E)	0.932	0.949	0.983	0.901	0.974	0.792	1.000

Table 70. Taxa data and statistics for the household shellfish networks.

Nodes	Nodes	Transactions	Households	Communities	Non-Household nodes (P, I)	Non-Household nodes (?, O)
Octopus dofleini	68	56	44	11	9	12
Paralithodes sp. and Lithodes sp.	64	56	53	8	2	4
Katharina tunicata	34	25	21	8	9	2
Chionoecetes bairdi and C. opilio	24	14	15	7	2	3
class Bivalia	16	10	9	7	5	2
Saxidomus giganteus	12	8	4	3	8	0
Strongylocentrotus droebachiensis	11	8	8	3	3	1
Clincardium sp.	8	4	6	3	0	1
Siliqua sp.	7	4	4	5	0	1
Cancer magister	6	3	3	5	1	1
Statistics						
Mean	25.20	18.80	16.70	4.00	2.70	1.80
Standard Error	7.32	6.52	5.62	1.13	1.10	0.55
Median	14.50	9.00	8.50	3.00	1.50	1.50
Mode	#N/A	56.00	4.00	0.00	1.00	0.00
Standard Deviation	23.14	20.62	17.78	3.56	3.47	1.75
Sample Variance	535.51	425.29	316.01	12.67	12.01	3.07
Kurtosis	0.24	0.52	0.91	-1.46	7.11	-0.56
Skewness	1.28	1.42	1.46	0.46	2.56	0.69
Range	62.00	53.00	50.00	9.00	12.00	5.00
Minimum	6.00	3.00	3.00	0.00	0.00	0.00
Maximum	68.00	56.00	53.00	9.00	12.00	5.00
Sum	252.00	188.00	167.00	40.00	27.00	18.00
Count	10.00	10.00	10.00	10.00	10.00	10.00
Confidence Level(95.0%)	16.55	14.75	12.72	2.55	2.48	1.25

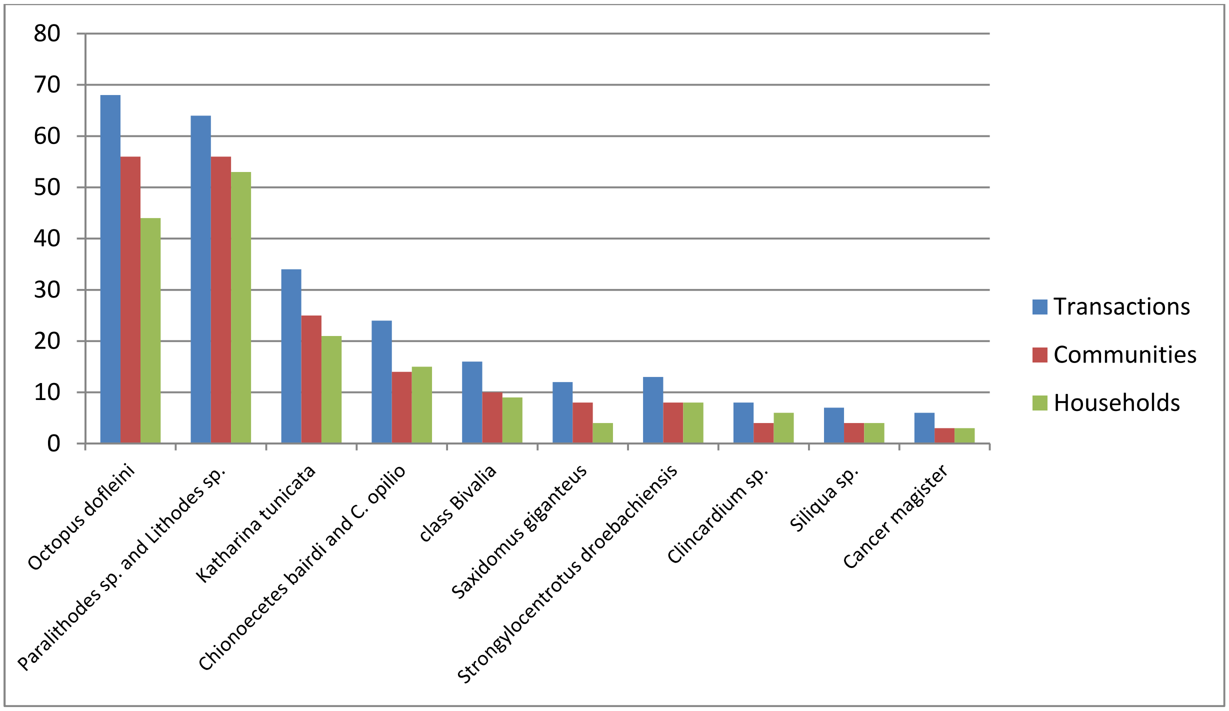

Figure 44. Household shellfish network data for taxa.

Table 71. The top 20 household providers of shellfish in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
3280	1	17	20	20	0	-20
3283	2	10	12	12	0	-12
75	1	10	15	12	3	-9
81	1	5	14	12	2	-10
3287	1	8	8	8	0	-8
35	2	8	9	7	2	-5
87	2	5	8	5	3	-2
3497	2	5	5	5	0	-5
72	1	3	5	5	0	-5
3401	1	3	5	5	0	-5
71	1	5	8	4	4	0
3330	1	4	4	4	0	-4
3309	1	3	4	4	0	-4
2432	1	1	4	4	0	-4
62	2	6	9	3	6	3
47	1	4	7	3	4	1
82	1	4	8	3	5	2
74	1	4	8	3	5	2
3317	1	3	3	3	0	-3
2297	1	2	3	3	0	-3
INDEX OF RETURN (mean)						-4.55

Table 72. The top 20 household receivers of shellfish in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
62	2	6	9	3	6	3
39	2	5	6	0	6	6
82	1	4	8	3	5	2
74	1	4	8	3	5	2
83	1	6	7	2	5	3
29	1	3	6	1	5	4
56	1	3	5	0	5	5
71	1	5	8	4	4	0
47	1	4	7	3	4	1
2	2	5	6	2	4	2
3329	1	4	6	2	4	2
13	1	5	5	1	4	3
46	1	3	4	0	4	4
15	1	3	4	0	4	4
66	1	3	4	0	4	4
64	1	3	4	0	4	4
2810	1	1	4	0	4	4
3410	1	1	4	0	4	4
75	1	10	15	12	3	-9
87	2	5	8	5	3	-2
INDEX OF RETURN (mean)						2.3

Household Plant Distribution Networks

One of the things that makes the plant and berry networks interesting is that they are dominated by women who do the majority of the plant harvesting and collecting. Every other network described in this report is primarily made up of males, although females do participate in every one of them. Of the 22 networks of plant redistribution, four have the majority of the participants and transactions (Figure 45, Table 73). Six of the seven largest networks are also focused around a single key node branching off into multiple connections. This makes these networks somewhat vulnerable. On the other hand, no major equipment is needed for participation in this system, and with limited resources, any household can participate.

Figure 46 shows the distribution of the network data. Standing out from these data is the lack of correlation between community and the other variables (Table 74). The reason for this is that plants networks tend to be community based, with only small amounts being sent to relatives in other places. In fact, the plant networks, other than the expected relationships between nodes, transactions, and households, has the lowest correlation coefficients in the data presented.

As in the individual networks, salmonberry, crowberry, and several species of *Vaccinium* are the primary plants in all transactions (Table 75), and the overwhelming dominance of the various berries in subsistence can be seen in Figure 47.

When considering the top 20 providers of plant foods (Table 76), and the top 20 receivers of plant foods (Table 77), we get an RI = -2.5 and RI= 2.3, very even in distribution. We also find that most of the top providers also received plant products, while most of the top receivers did not participate in production.

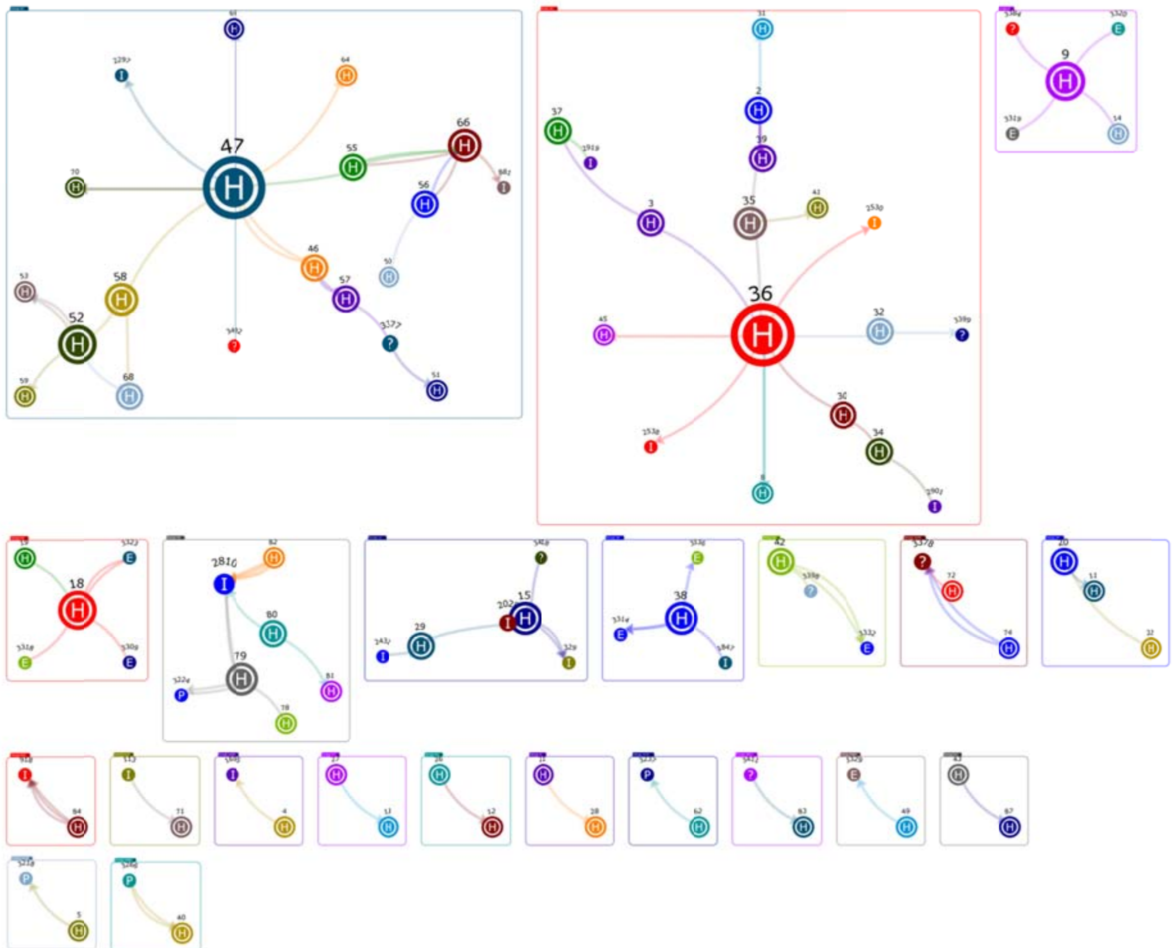

Figure 45. Plant distribution networks for households.

Table 73. Plant network data.

Network	Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non-Household nodes (E)
1	20	27	3	16	2	2	0
2	18	20	2	13	4	1	0
5	7	12	2	5	0	0	0
6	6	9	3	2	0	1	0
4	5	5	4	2	2	0	3
3	5	4	4	2	3	1	2
7	4	4	2	1	1	0	2
8	3	3	1	1	0	1	1
9	3	3	1	2	0	1	0
13	2	3	2	1	0	0	0
10	3	2	1	3	1	0	0
12	2	2	1	1	1	0	0
11	2	1	2	1	1	0	0
14	2	1	1	1	1	0	0
15	2	1	1	1	1	0	0
16	2	1	1	2	0	0	0
17	2	1	1	2	0	0	0
18	2	1	1	2	0	0	0
19	2	1	2	1	1	0	0
20	2	1	2	1	0	1	0
21	2	1	2	1	0	0	1
22	2	1	1	2	0	0	0
Statistics							
Mean	4.45	4.73	1.82	2.86	0.82	0.36	0.41
Standard Error	1.05	1.44	0.20	0.83	0.23	0.12	0.18
Median	2.00	2.00	2.00	2.00	0.50	0.00	0.00
Mode	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Standard Deviation	4.94	6.78	0.96	3.91	1.10	0.58	0.85
Sample Variance	24.45	45.92	0.92	15.27	1.20	0.34	0.73
Kurtosis	6.34	5.71	0.56	7.53	2.38	1.20	3.50
Skewness	2.63	2.44	1.11	2.85	1.58	1.39	2.08
Range	18.00	26.00	3.00	15.00	4.00	2.00	3.00
Minimum	2.00	1.00	1.00	1.00	0.00	0.00	0.00
Maximum	20.00	27.00	4.00	16.00	4.00	2.00	3.00
Sum	98.00	104.00	40.00	63.00	18.00	8.00	9.00
Count	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Confidence Level(95.0%)	2.19	3.00	0.42	1.73	0.49	0.26	0.38

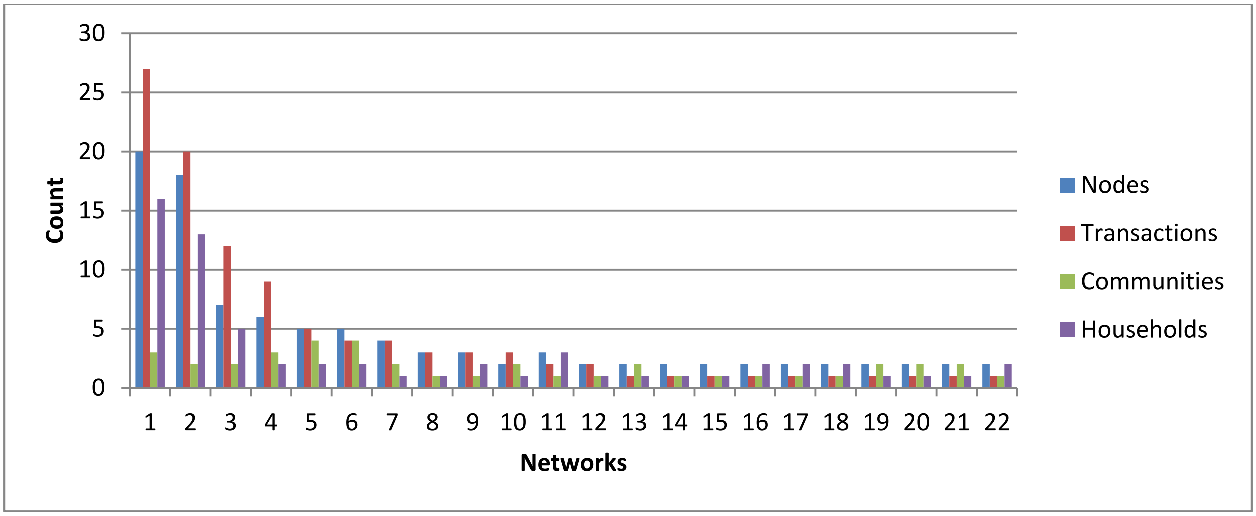

Figure 46. Plot of plant household harvests for the network data.

Table 74. Correlation coefficients for plant network data.

	Nodes	*Transactions*	*Communities*	*Households*	*Non-Household nodes (P, I)*	*Non-Household nodes (?, O)*	*Non-Household nodes (E)*
Nodes	1.000						
Transactions	0.980	1.000					
Communities	0.410	0.417	1.000				
Households	0.972	0.950	0.260	1.000			
Non- Household nodes (P, I)	0.701	0.723	0.239	0.616	1.000		
Non- Household nodes (?, O)	0.686	0.679	0.381	0.631	0.333	1.000	
Non- Household nodes (E)	-0.024	-0.062	0.619	-0.168	-0.273	-0.026	1.000

Table 75. Plant taxa distribution in the household networks.

Nodes	Transactions	Communities	Households	Non-Household nodes (P, I)	Non-Household nodes (?, O)	Non- Household nodes (E)
Empetrum nigrum	39	30	29	1	4	3
Rubus chamaemorus	34	23	20	2	2	4
Vaccinium uliginosum	15	9	8	6	0	1
Ligusticum scoticum	9	5	7	0	0	1
Berries-unknown	9	5	8	1	0	0
Frageria chiloensis	8	4	7	0	1	0
Polygonum alpinum	8	4	6	8	2	0
Vaccinium ovalifolium	7	4	5	1	0	0
Epilobium angustifolium	7	7	5	0	0	0
Huckleberries	5	3	2	3	0	1
Vaccinium vitis-idaea	4	2	3	2	0	0
Heracleum lanatum	4	2	2	0	0	1
Wineberries	4	2	3	0	0	1
Mushrooms	2	1	1	1	1	0
Tundra Tea	2	1	2	2	0	0
Honchenya peploides	2	1	1	1	0	0
Athyrium felix-famine	2	1	1	1	0	0
Statistics						
Mean	9.47	6.12	6.47	1.71	0.59	0.71
Standard Error	2.61	1.96	1.79	0.53	0.27	0.28
Median	7.00	4.00	5.00	1.00	0.00	0.00
Mode	2.00	1.00	2.00	1.00	0.00	0.00
Standard Deviation	10.77	8.08	7.39	2.20	1.12	1.16
Sample Variance	115.89	65.36	54.64	4.85	1.26	1.35
Kurtosis	4.07	5.09	5.35	3.93	4.69	3.79
Skewness	2.18	2.37	2.29	2.02	2.16	2.02
Range	37.00	29.00	28.00	8.00	4.00	4.00
Minimum	2.00	1.00	1.00	0.00	0.00	0.00
Maximum	39.00	30.00	29.00	8.00	4.00	4.00
Sum	161.00	104.00	110.00	29.00	10.00	12.00
Count	17.00	17.00	17.00	17.00	17.00	17.00

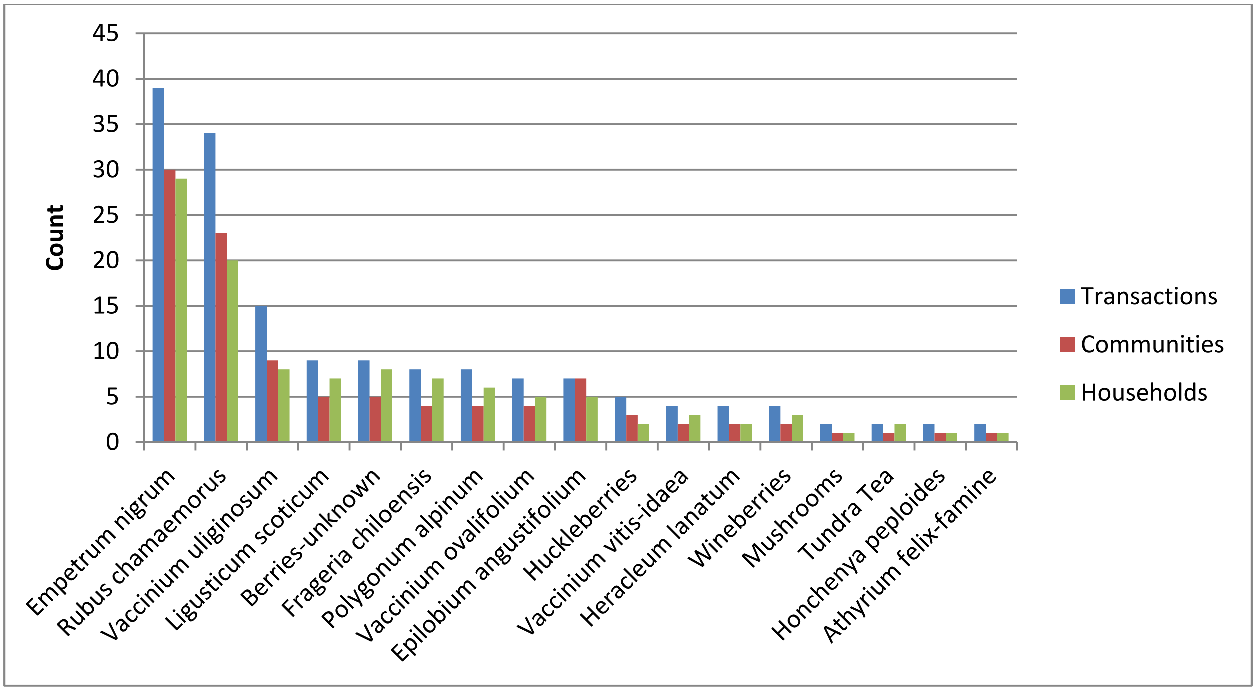

Figure 47. Plant taxa in the household networks and their distributions.

Table 76. Table 109. The top 20 household providers of plants in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
36	2	8	9	9	0	-9
47	1	8	10	9	1	-8
52	1	4	5	5	0	-5
82	5	1	5	5	0	-5
2028	6	2	5	4	1	-3
2	2	2	4	4	0	-4
15	6	3	7	3	4	1
38	7	3	4	3	1	-2
55	1	2	4	3	1	-2
84	13	1	3	3	0	-3
66	1	3	6	2	4	2
2810	5	3	8	2	6	4
35	2	3	3	2	1	-1
42	8	2	3	2	1	-1
80	5	2	2	2	0	-2
46	1	2	4	2	2	0
3377	1	2	2	2	0	-2
3266	12	1	2	2	0	-2
74	9	1	2	2	0	-2
3323	4	1	2	2	0	-2
INDEX OF RETURN (mean)						-2.3

Table 77. The top 20 household receivers of plants in the project area.

Household	Network	Nodes	Transactions	Transactions Out	Transactions In	Return
2810	5	3	8	2	6	4
18	4	4	5	0	5	5
9	3	4	4	0	4	4
66	1	3	6	2	4	2
15	6	3	7	3	4	1
79	5	3	5	1	4	3
39	2	2	4	0	4	4
58	1	3	3	0	3	3
3378	9	2	3	0	3	3
57	1	2	3	0	3	3
918	13	1	3	0	3	3
29	6	2	2	0	2	2
30	2	2	2	0	2	2
56	1	2	3	1	2	1
3	2	2	2	0	2	2
46	1	2	4	2	2	0
70	1	1	2	0	2	2
53	1	1	2	0	2	2
8	2	1	2	0	2	2
3332	8	1	2	0	2	2
INDEX OF RETURN (mean)						2.5

NETWORK VULNERABILITY

One of the key foci of this study, once the network analyses had been completed, is to use these networks to investigate vulnerability and resilience. As stated above, there are two kinds of networks in these data. Star or clustered networks tend to be found where a single network node dominates the overall structure. Should that node be removed from the network, the entire network may fall apart. Clustered or decentralized networks on the other hand, are often much more durable because there are a number of key nodes in the network and everyone has multiple connections. Should one of those primary nodes disappear, then there is enough structure to create new links between nodes and maintain access to critical resources.

One of the important functionalities of our network tool is the ability to create a network, analyze the data for that network, and then remove a key node and re-compute the data. This gives us a measure of the loss in transactions, loss in nodes (connectivity), and primarily, loss in access. Of course, this is best used only for the larger networks, and smaller networks with only 2-3 nodes are always destroyed when the key provider leaves the network.

The best example of this is the terrestrial mammal networks. If we look at the three largest networks, the one on the left is a star pattern network where the entire distribution system is controlled by a single individual (Figure 48). Should this individual take another job, move to another community, or die, the entire redistribution of cattle meats would be severely disrupted. On the top right is the network for redistribution of moose meat from sport hunters. Exactly like the cattle network, but now based on sport hunters, this network would disappear if there were too few moose for the sport hunters, or some regulations changed. These sorts of centralized networks are very vulnerable to changes in key nodes.

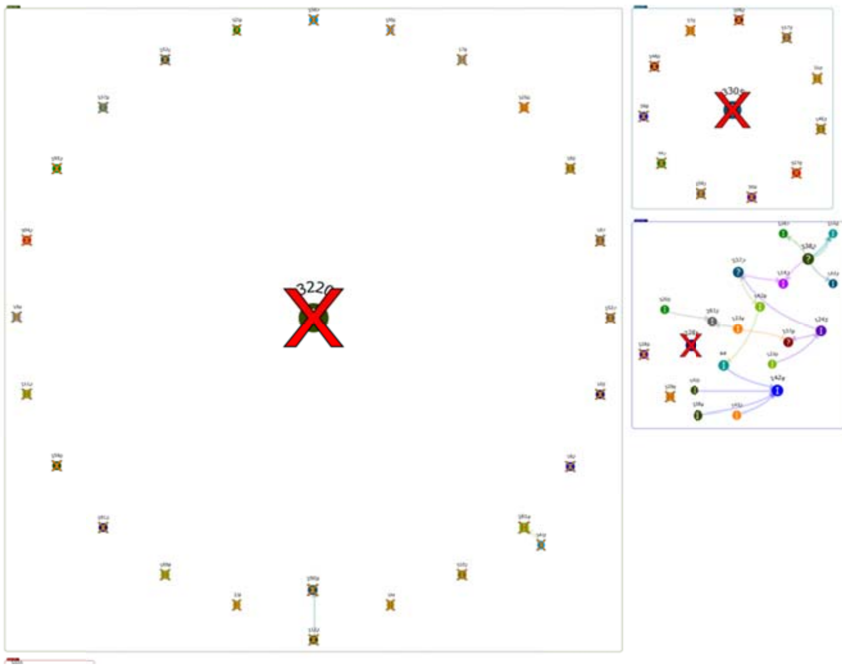

Figure 48. Vulnerability in the three largest terrestrial mammal networks.

Here we see that the third network, one that is a cluster or decentralized type, has much more stability. Removing the key provider in the network had only a small effect on the overall connections and transactions (Table 78). In fact, the loss of the key provider in the caribou network results in a 15 percent loss in nodes, and a 17 percent loss in transactions.

Table 78. Vulnerability and network loss in terrestrial mammal networks.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	27	36	0	0	0.00	0.00
2	12	11	0	0	0.00	0.00
3	21	23	18	19	0.86	0.83

Another important network that appears highly vulnerable is associated with shellfish, particularly the centralized sections of the network that are a product of the canneries. In Figure 49 we find that with the loss of the cannery, the entire section associate with the cannery becomes disarticulated from the network with a 17 percent loss, but still maintains much of its shape because of the strength of the octopus and chiton networks embedded in the same network. The second network is more vulnerable, losing 36 percent of its transactions with the loss of the cannery (Table 79).

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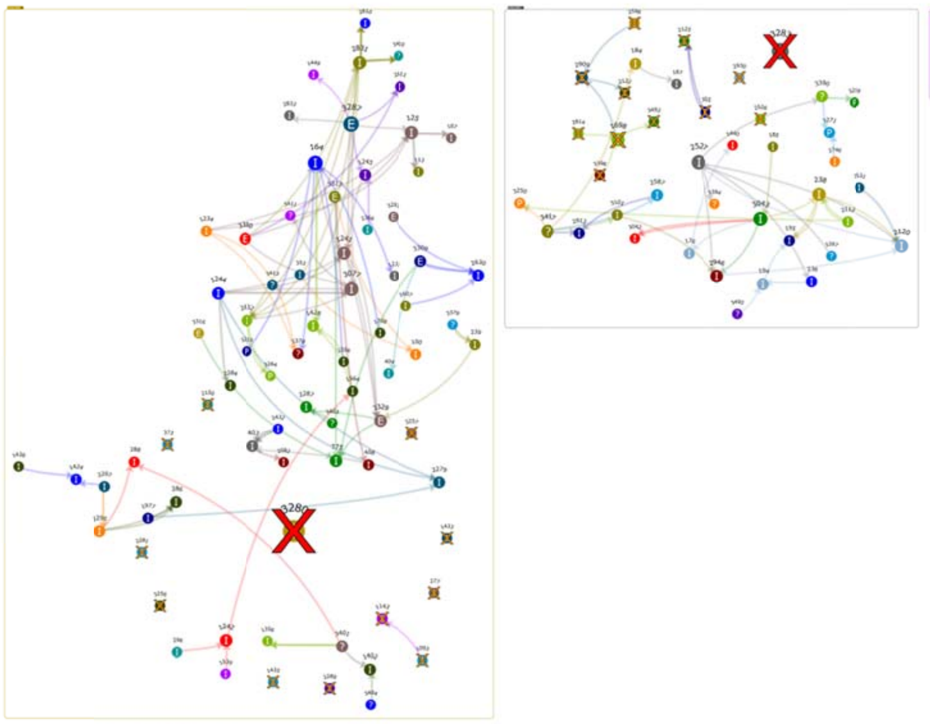

Figure 49. Projected loss of two canneries on the distribution of King Crab.

Table 79. Vulnerability and network loss in shellfish networks.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	76	121	64	100	0.84	0.83
2	40	56	28	36	0.70	0.64

The sea mammal redistribution networks have a structure very similar to the caribou network above (Figure 50). Looking at only the largest network, and removing the largest provider, we get a 15 percent reduction in the number of nodes, and a 30 percent reduction in the number transactions. An interesting consequence is that this would be a loss of almost all Steller sea lion transactions (Table 80).

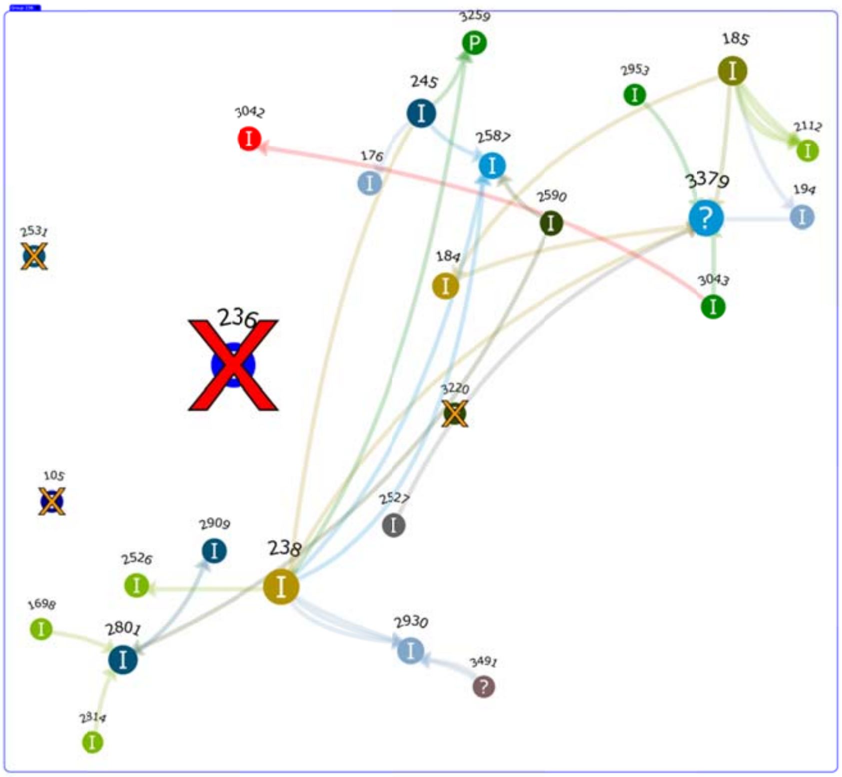

Figure 50. Removal of the top hunter in the largest sea mammal distribution network.

Table 80. Vulnerability and network loss in the largest sea mammal distribution network.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	26	46	22	32	0.85	0.70

Bird networks, because they are small and poorly connected, are vulnerable to disruption. While the largest network is a cluster pattern, the three smaller ones in Figure 51 are star pattern networks. The loss of the major provider in the largest network result is a net loss of 6 percent of nodes and 22 percent of transactions. But for the star pattern networks, the loss is 100 percent (Table 81).

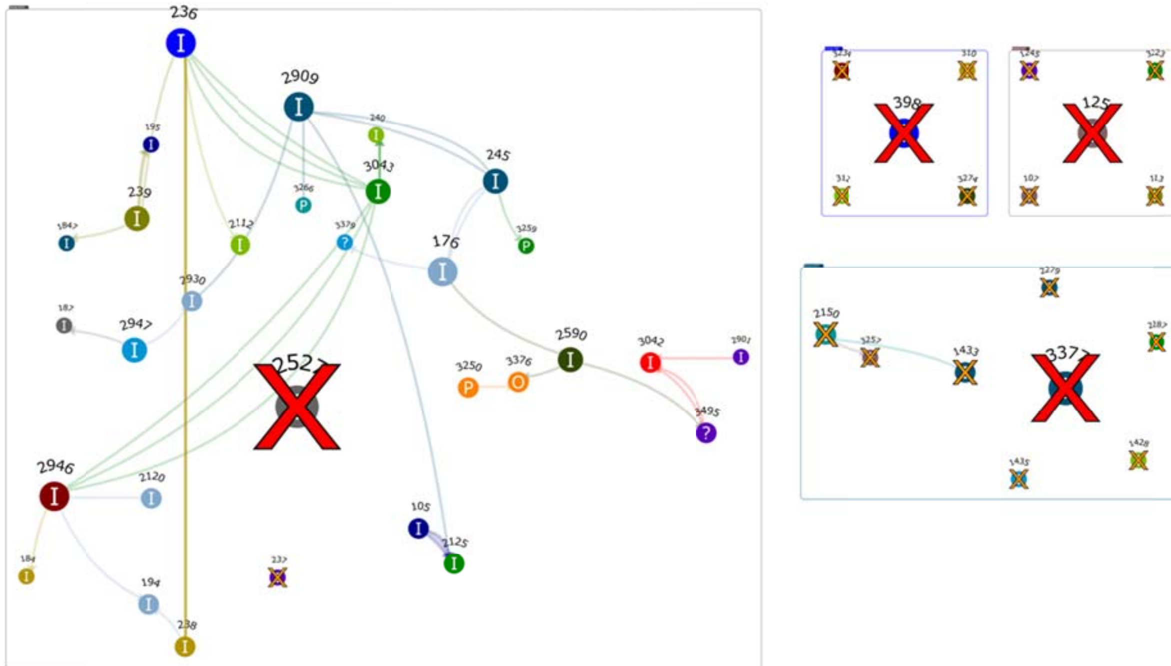

Figure 51. Removal of the top hunter in the bird and egg networks.

Table 81. Vulnerability and network loss in four of the five largest bird and egg distribution networks.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	31	59	29	46	0.94	0.78
3	8	11	0	0	0.00	0.00
4	5	7	0	0	0.00	0.00
5	5	4	0	0	0.00	0.00

Loss of the two biggest providers of salmon in the largest salmon network, and one each on the next two largest, results in a loss of nodes and connections between 12 and 35 percent (Figure 52, Table 82). Overall, these cluster or decentralized networks are fairly stable. Because the salmon networks are so critically dependent on the commercial salmon harvest, and because that harvest still has a large number of local participants, we consider the salmon networks to be durable and resilient.

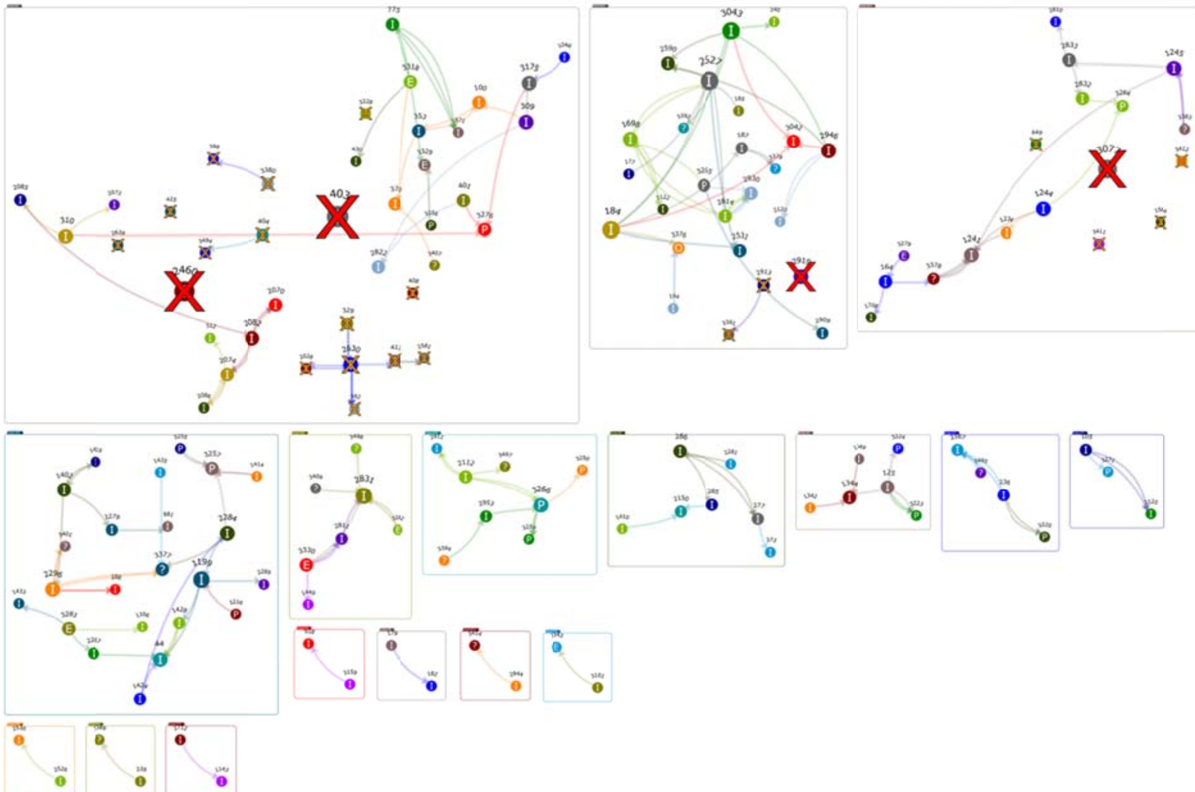

Figure 52. Salmon networks with the largest providers removed from the three largest networks.

Table 82. Vulnerability and network loss in the three largest salmon distribution networks.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	40	62	27	40	0.68	0.65
2	25	45	22	38	0.88	0.84
3	18	27	13	18	0.72	0.67

Final examples of network vulnerability are the plant foods (Figure 53, Table 83). Plant networks are smaller, more vulnerable, and almost wholly dependent on women. The effects of an important female provider leaving one of these networks is catastrophic, with a 50-100 percent loss of network transactions by the loss of a single provider.

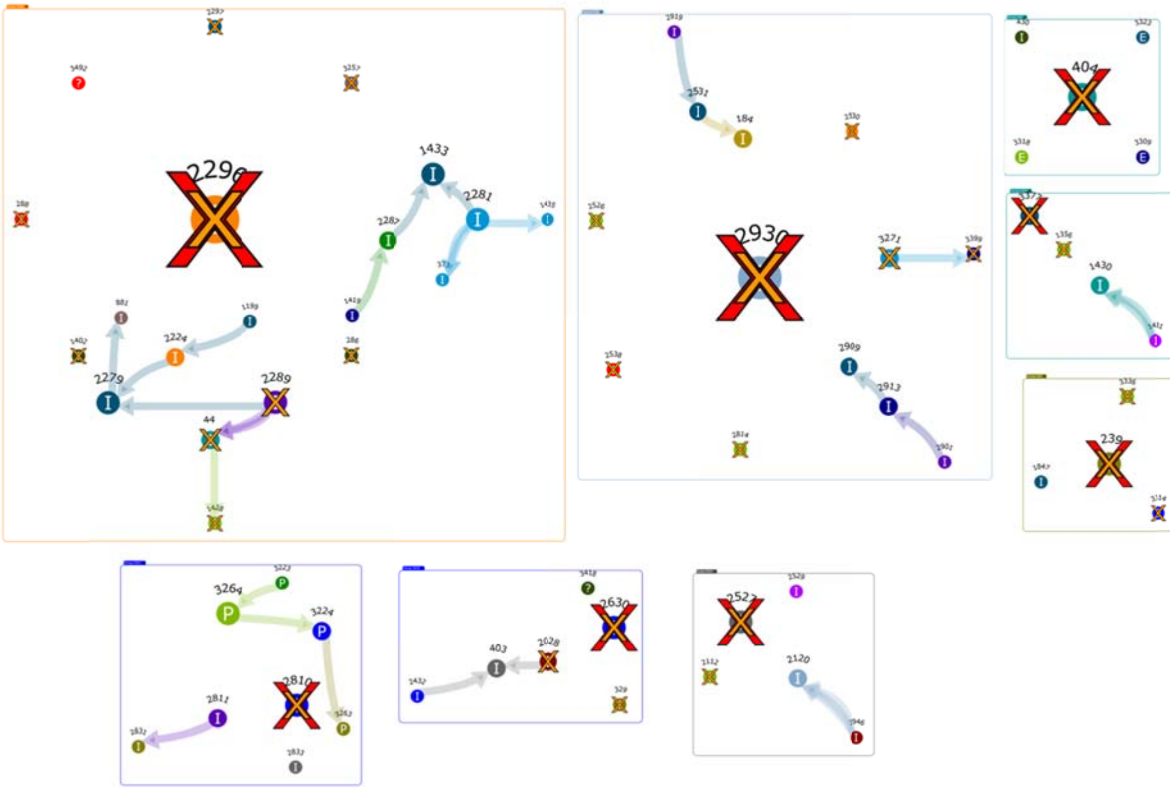

Figure 53.Vulnerability analysis of plant food networks.

Table 83. Vulnerability and network loss in the plant distribution networks.

Network	*Nodes*	*Transactions*	*Nodes Remaining After Removal of Major Node*	*Transactions After Removal of Major Node*	*Percent of Network Nodes After Loss of Key Node*	*Percent of Network Transactions after Loss of Key Node*
1	20	23	11	9	0.55	0.39
2	13	13	6	4	0.46	0.31
3	5	5	4	0	0.80	0.00
4	4	6	0	0	0.00	0.00
5	8	12	7	4	0.88	0.33
6	6	9	3	1	0.50	0.11
7	5	6	3	3	0.60	0.50

CONCLUDING NETWORK ANALYSIS

In Chapter 2, based on the work of Maschner and Bentley (2003), there are a series of expectations in regards to scale-free networks.

1. “We expect these to be fractal, or scale free networks.” In Table 84, the Total Transactions, Transactions out, and Number of Nodes are all correlated (r > .80). One clear sign that these are not fractal or scale free networks is that the majority of the data are trending towards a normal distribution (Figures 54, 55), yet all are somewhat skewed to the left. The one histogram that is clearly not normally distributed is “Transactions-out.” In fact, Figure 56 shows that “Transactions out” might indeed be a powerlaw distribution and thus trending towards part of a scale free network. But how are the other variables distributed? The left skew to these charts indicates that there is a trend towards a lot of households with few nodes or transactions, and a smaller set with large numbers of nodes and transactions, as seen in Table 84.

2. “The second common feature is that agents all act with similar goals, but due to differences in the interconnectedness of each agent, some agents increase their attributes at the expense of others “the rich get richer,” so to speak.” Table 85 shows clearly that there is a differential distribution in the spread of connections as measured by “Transactions in” and “Transactions out.” We see this as well in the left skew of the histograms in Figure 55. Those with more connections do not have disproportionally more transactions as we would expect, although “the rich get richer” concept might be present in other categories of return for which we have no measure.

3. “Similarly, if the most powerful or popular people are the most likely to acquire new connections, they will become the most well-connected agents in a scale-free social network.” Since this is not a diachronic study, we have no way of knowing whether or not those with the most connections actually acquire new connections at a greater rate than those with fewer connections.

To address numbers 2 and 3, income is used as a proxy measure. In Table 85 we sorted 84 surveyed households based on the number of “Transactions out,” – a measure of how much they give away. A simple histogram comparison and t-test (Figure 57) shows that there is no difference in income between the bottom half of the producers, and the top half of the producers (T = 1.62, df = 76, p=.11). This means that income has no bearing on whether or not one gives away subsistence goods. But one important variable appears to be having a commercial fishing permit and boat. In Figure 58 we present the same 84 households, only this time their transactions out are distributed based on whether or not they have a boat and permits. What we find here is that access to a boat is significant in regards to the number of subsistence transactions one gives away (T = 4.33, df = 83, p<.001).

4. “The majority of agents in a scale-free network are poorly connected, while the majority of links tend to lead through a few highly connected agents. In fact, a histogram of connections held by agents in a scale-free network is a power law distribution. This contrasts with a random network in which all agents have the same probability of acquiring connections which leads to a

normal distribution of connections per agent.” We found in the previous sections that the majority of agents are indeed poorly connected, and links do tend to flow through a few very well connected nodes. On the other hand, we did not find that these were scale free networks, but they are trending that direction because all households certainly do not have the same probability of acquiring connections. Against expectations, we did not find that the best connected have disproportionately more connections, but this might be true if we did the analysis for individual taxa categories.

5. “*An important implication of a scale-free network is its multifaceted vulnerability to catastrophic change.* A scale-free network (such as in this case, a sharing network) is organized around a limited number of highly-connected agents, which are highly vulnerable, as the removal of a few of the most well-connected agents breaks up the network considerably.” Again, trending towards a scale free network, we found this to be true. Our vulnerability analysis showed considerable dissolution of network strength with the removal of a key node for many of the networks, but not for others.

The overall implication of statistically verifying of the role of a commercial permit / boat in the harvest and redistribution of subsistence goods is transformative. Reedy-Maschner (e.g. 2007, 2010) has argued numerous times that this is qualitatively the case. But here we have actually measured the relationship between boat ownership and subsistence sharing. Boat owners have more access, but boat owners also tend to be more entrepreneurial, and we would expect them to attract more connections across a broad range of transactions.

The results of these analyses allow us to speculate on ***thresholds that are vulnerable to development.*** There are two broad areas of thresholds, and two possible scenarios in each.

First, we must consider who might participate in development activities such that they would give up their current activities to work in the oil and gas development business. If the most entrepreneurial individuals, which in this case include many with commercial fishing permits, were to leave fishing and participate in development activities, this would be catastrophic to regional subsistence activities and access to subsistence goods. If those currently without commercial fisheries, including those that today hold wage positions in local communities, or those currently unemployed were to begin participating in jobs associated with potential oil and gas development, we would expect the status quo in regards to subsistence, and the increased income may also translate into increased subsistence activities.

Second, if there was a major disruption in access to subsistence because of an environmental catastrophe caused by development, then the commercial fishermen who now provide the most subsistence goods would be severely impacted. This would cause a halt in both commercial fishing activities and in nearly all subsistence activities since, as we showed above, those with boats and permits are the most important providers of subsistence goods.

Scatterplot Matrix

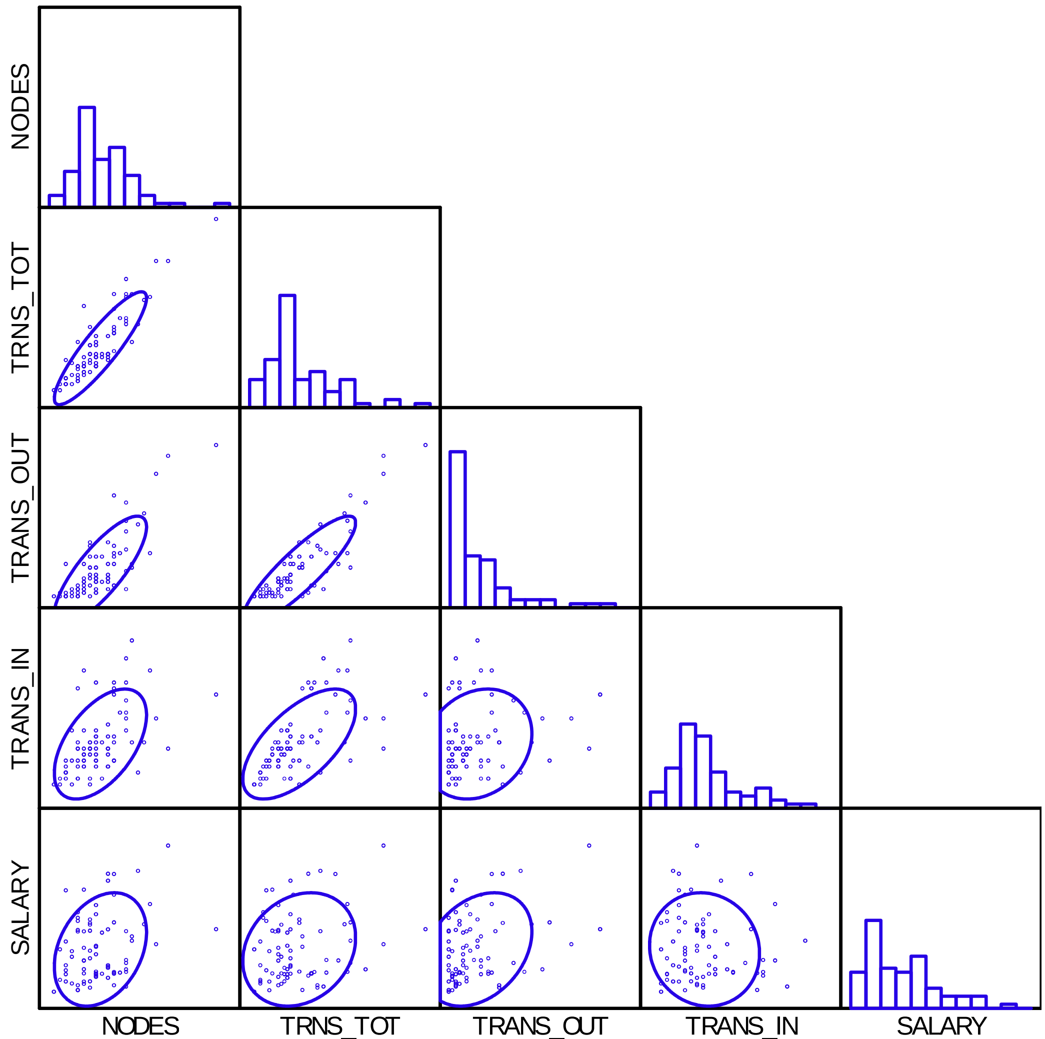

Figure 54. Scatterplot of key household transaction data. Nodes are highly correlated with total transactions, and transactions out. But less so with transactions in. None are correlated with salary.

Table 84. Correlations coefficients for the important variables in the household transaction networks.

Pearson Correlation Matrix					
	NODES	TOTAL TRANSACTIONS	TRANSACTIONS OUT	TRANSACTIONS IN	SALARY
NODES	1.000				
TOTAL TRANSACTIONS	0.889	1.000			
TRANSACTIONS OUT	0.802	0.878	1.000		
TRANSACTIONS IN	0.529	0.636	0.190	1.000	
SALARY	0.303	0.207	0.311	-0.071	1.000

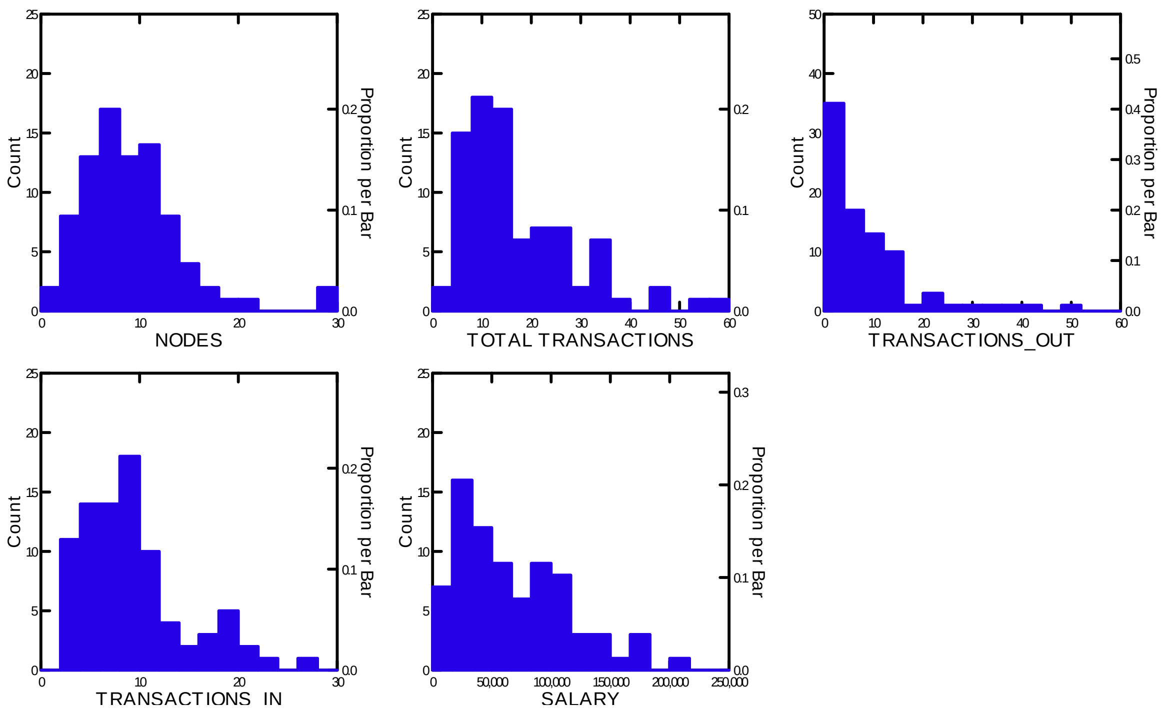

Figure 55. Histograms of household network data.

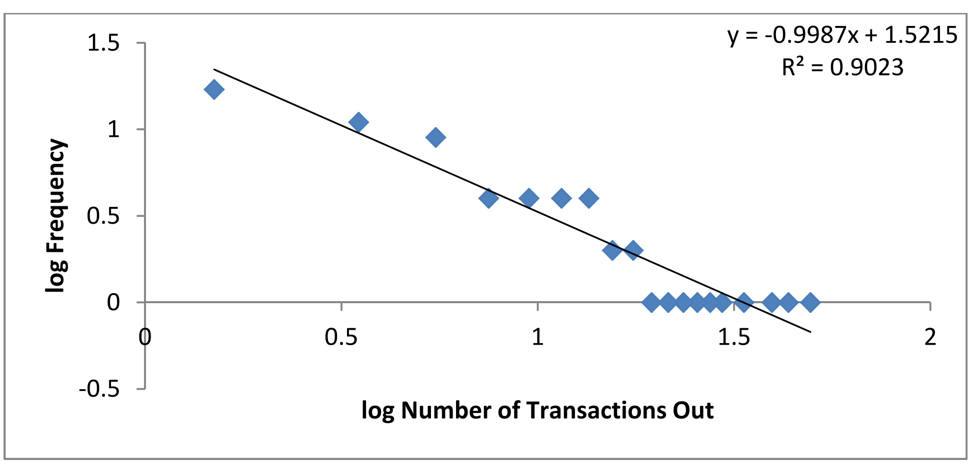

Figure 56. Power law distribution of transactions out.

Table 85. Transaction and salary data for 88 households surveyed.

Nodes	Transactions	Transactions Out	Transactions In	salary	log nodes	log transactions	log trans out	log trans in	log salary
28	55	50	5		1.447158	1.740362689	1.69897	0.69897	#NUM!
28	59	42	17	93910	1.447158	1.770852012	1.623249	1.2304489	4.9727118
20	45	39	8	209819	1.30103	1.653212514	1.591065	0.90309	5.3218448
18	45	34	13	72870	1.2552725	1.653212514	1.531479	1.1139434	4.8625488
11	34	28	6	103270	1.0413927	1.531478917	1.447158	0.7781513	5.0139742
13	39	26	13	38305	1.1139434	1.591064607	1.414973	1.1139434	4.5832555
16	32	23	9	100715	1.20412	1.505149978	1.361728	0.9542425	5.0030942
13	33	21	14	34561	1.1139434	1.51851394	1.322219	1.146128	4.5385863
15	24	20	4	174725	1.1760913	1.380211242	1.30103	0.60206	5.242355
13	34	18	16	46810	1.1139434	1.531478917	1.255273	1.20412	4.6703386
7	17	15	2	102610	0.845098	1.230448921	1.176091	0.30103	5.0111897
10	20	15	5	170840	1	1.301029996	1.176091	0.69897	5.2325896
7	23	14	9	12610	0.845098	1.361727836	1.146128	0.9542425	4.1007151
11	23	14	9	16107	1.0413927	1.361727836	1.146128	0.9542425	4.2070147
13	24	13	11	91040	1.1139434	1.380211242	1.113943	1.0413927	4.9592322
14	24	13	11		1.146128	1.380211242		1.0413927	#NUM!
12	26	12	14	33708	1.0791812	1.414973348	1.079181	1.146128	4.527733
17	33	12	21	128513	1.2304489	1.51851394	1.079181	1.3222193	5.1089471
11	29	12	17	170255	1.0413927	1.462397998	1.079181	1.2304489	5.2310999
12	25	12	13		1.0791812	1.397940009		1.1139434	#NUM!
9	14	11	3	31914	0.9542425	1.146128036	1.041393	0.4771213	4.5039812
11	21	11	10	32010	1.0413927	1.322219295	1.041393	1	4.5052857
8	17	11	6	35110	0.90309	1.230448921	1.041393	0.7781513	4.5454308
7	14	11	3	53292	0.845098	1.146128036	1.041393	0.4771213	4.726662
3	12	9	3	31405	0.4771213	1.079181246	0.954243	0.4771213	4.4969988
10	14	9	5	41770	1	1.146128036	0.954243	0.69897	4.6208645
6	30	9	21	50505	0.7781513	1.477121255	0.954243	1.3222193	4.7033344
14	18	9	9	83798	1.146128	1.255272505	0.954243	0.9542425	4.9232337
11	15	9	6	141609	1.0413927	1.176091259	0.954243	0.7781513	5.1510909
8	18	8	10	69360	0.90309	1.255272505	0.90309	1	4.8411091
14	34	8	26	77791	1.146128	1.531478917	0.90309	1.4149733	4.8909294
7	17	8	9	107303	0.845098	1.230448921	0.90309	0.9542425	5.0306119
8	10	8	4		0.90309	1		0.60206	#NUM!
13	26	7	19	50930	1.1139434	1.414973348	0.845098	1.2787536	4.7069737
7	14	6	8	64010	0.845098	1.146128036	0.778151	0.90309	4.8062478
10	14	6	8	93760	1	1.146128036	0.778151	0.90309	4.9720176
8	14	6	10	114540	0.90309	1.146128036	0.778151	1	5.0589572
7	12	5	7	21610	0.845098	1.079181246	0.69897	0.845098	4.3346548
10	13	5	8	26450	1	1.113943352	0.69897	0.90309	4.4224257
10	12	5	7	40105	1	1.079181246	0.69897	0.845098	4.6031985
8	13	5	8	70665	0.90309	1.113943352	0.69897	0.90309	4.8492044
6	10	5	5	90810	0.7781513	1	0.69897	0.69897	4.9581337
8	10	5	5	127130	0.90309	1	0.69897	0.69897	5.104248
8	11	4	7	32620	0.90309	1.041392685	0.60206	0.845098	4.513484
10	14	4	10	43810	1	1.146128036	0.60206	1	4.6415733
6	10	4	6	50320	0.7781513	1	0.60206	0.7781513	4.7017406
8	10	4	6	58817	0.90309	1	0.60206	0.7781513	4.7695029
6	10	4	6	67865	0.7781513	1	0.60206	0.7781513	4.8316459
9	13	4	9	89139	0.9542425	1.113943352	0.60206	0.9542425	4.9500678
4	6	4	2		0.60206	0.77815125		0.30103	#NUM!
6	11	3	8	17985	0.7781513	1.041392685	0.477121	0.90309	4.2549104
11	21	3	18	32970	1.0413927	1.322219295	0.477121	1.2552725	4.5181189
11	22	3	19	34311	1.0413927	1.342422681	0.477121	1.2787536	4.5354334

Nodes	Transactions	Transactions Out	Transactions In	salary	log nodes	log transactions	log trans out	log trans in	log salary
7	11	3	8	100245	0.845098	1.041392685	0.477121	0.90309	5.0010627
5	6	3	3	105220	0.69897	0.77815125	0.477121	0.4771213	5.0220983
13	25	2	23	14402	1.1139434	1.397940009	0.30103	1.3617278	4.1584228
5	10	2	8	15944	0.69897	1	0.30103	0.90309	4.2025973
4	4	2	2	18491	0.60206	0.602059991	0.30103	0.30103	4.2669604
6	7	2	5	21009	0.7781513	0.84509804	0.30103	0.69897	4.3224054
8	13	2	11	31350	0.90309	1.113943352	0.30103	1.0413927	4.4962375
6	13	2	11	38505	0.7781513	1.113943352	0.30103	1.0413927	4.5855171
5	10	2	8	92610	0.69897	1	0.30103	0.90309	4.9666579
5	5	2	3	117201	0.69897	0.698970004	0.30103	0.4771213	5.0689313
10	14	2	12	161272	1	1.146128036	0.30103	1.0791812	5.207559
5	7	1	6	8995	0.69897	0.84509804	0	0.7781513	3.9540012
2	4	1	3	23531	0.30103	0.602059991	0	0.4771213	4.3716404
8	10	1	9	27481	0.90309	1	0	0.9542425	4.4390325
8	20	1	19	29320	0.90309	1.301029996	0	1.2787536	4.467164
6	8	1	7	32310	0.7781513	0.903089987	0	0.845098	4.509337
4	7	1	6	63200	0.60206	0.84509804	0	0.7781513	4.8007171
3	6	1	5	147750	0.4771213	0.77815125	0	0.69897	5.1695275
6	8	1	7	148690	0.7781513	0.903089987	0	0.845098	5.1722818
1	5	1	4		0	0.698970004		0.60206	
1	2	0	2	7000	0	0.301029996		0.30103	3.845098
5	18	0	18	9435	0.69897	1.255272505		1.2552725	3.9747419
3	4	0	4	21245	0.4771213	0.602059991		0.60206	4.3272567
3	6	0	6	36831	0.4771213	0.77815125		0.7781513	4.5662135
3	4	0	4	43630	0.4771213	0.602059991		0.60206	4.6397852
4	11	0	11	55560	0.60206	1.041392685		1.0413927	4.7447622
2	2	0	2	65805	0.30103	0.301029996		0.30103	4.8182589
3	4	0	4	76753	0.4771213	0.602059991		0.60206	4.8850954
5	9	0	9	90492	0.69897	0.954242509		0.9542425	4.9566102
7	8	0	8	91710	0.845098	0.903089987		0.90309	4.9624167
5	5	0	5	109514	0.69897	0.698970004		0.69897	5.0394696
5	10	0	10		0.69897	1		1	

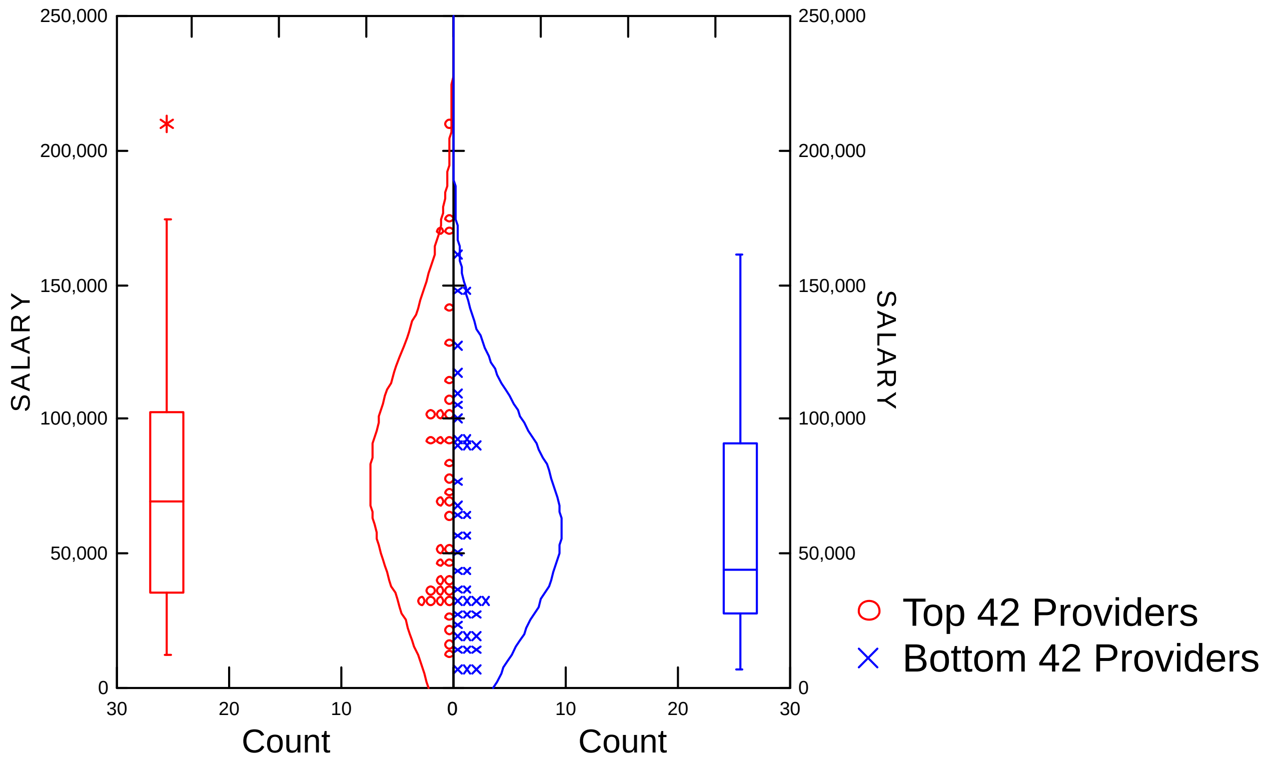

Figure 57. Splitting 84 households into the top 42 providers and the bottom 42 providers, we find that salary or income has no effect on how much one provides.

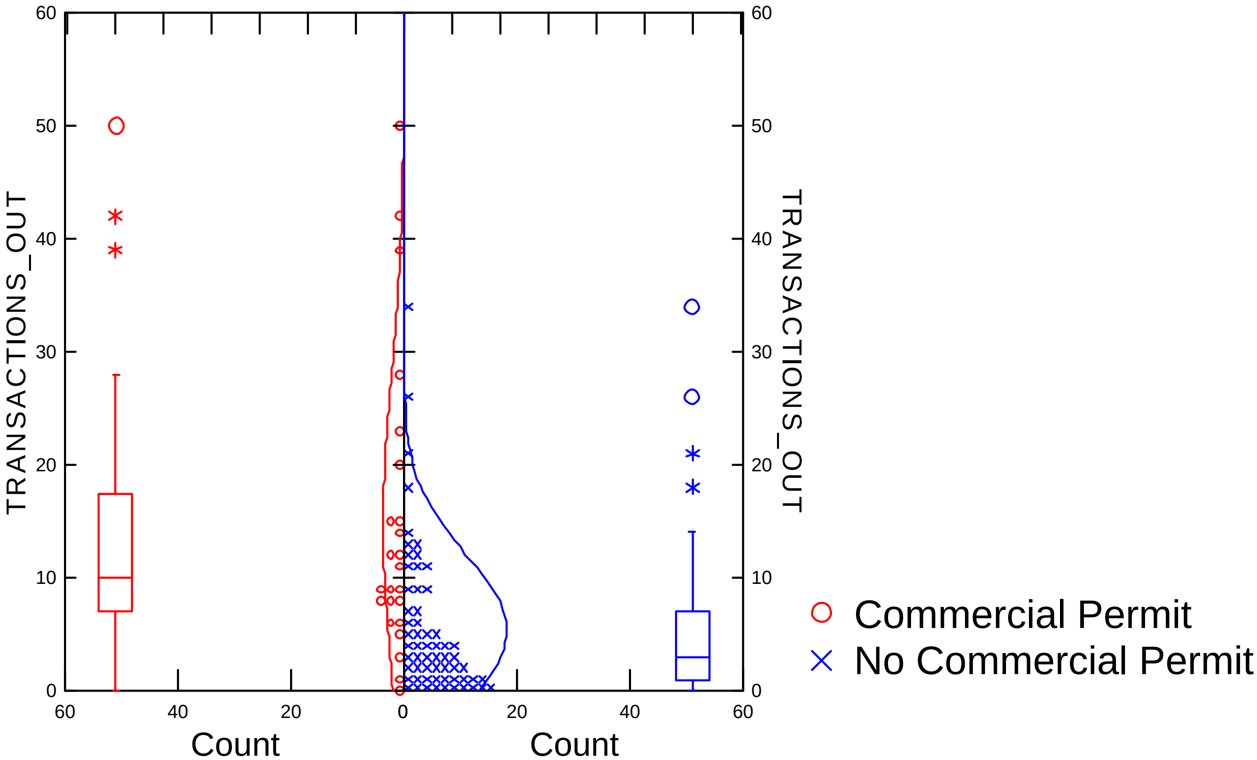

Figure 58. Commercial fishing permit ownership, and the boat to use that permit, is highly significant in the distribution of subsistence foods.