# IDS 564 - Final Project
# Dolphin Network Analysis

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**Background and Description:**

Over the course of our Social Media Analytics journey, we've learned a lot about different networks that are prevalent in today's world. The majority of these networks study human interaction, and how nodes representing humans are perceived to be with their respective edges. Admittingly, they give us a better understanding of how we as people operate and process information with one another given a group broken down into subgroups. However, what if we were able to tie in techniques that are used to study these human networks to animals? Well, we do just that by researching a bottlenose dolphin network and find some pretty intriguing, captivating results:

So what is the network exactly? It's a community of dolphins made up of a group of 62 male and female bottlenose dolphins living in Doubtful Island, New Zealand. We have David Lusseau, Karsten Schneider, Oliver J. Boisseau, Patti Haase, Elisabeth Slooten, and Steve M. Dawson for contributing to the study, and articles written about the network. Observations of the community of dolphins were conducted for 7 years from 1994-2001; these observations take note of the different dolphin relationships, subgroups, pairings, and more that take place. Each **node** represents a dolphin, and the **unweighted edges** between the nodes represent the frequent pairings and interactions occurring within the network. In terms of other **attributes** within the community, there are a couple known attributes that we're able to observe: the dolphin **gender**, and **name**.

Let's take a look at a couple tables and a visual from the article "*The bottlenose dolphin community of Doubtful Sound features a large proportion of long-lasting associations*" that go into a bit more depth on them:

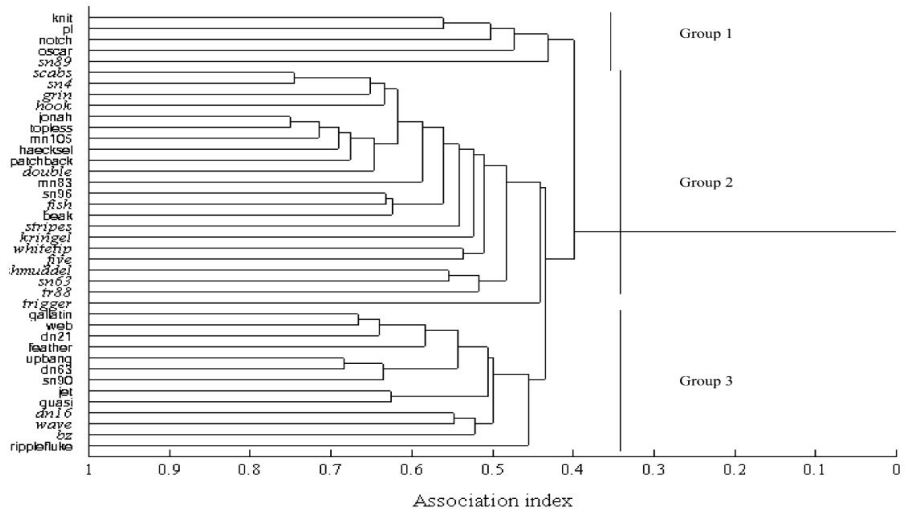



**Fig. 4** Average linkage dendrogram of the Doubtful Sound community for associations observed between 1995 and 2001. Females are represented in *italics*. The three groups described in the text are outlined

| | Average HWI (SD) | Maximum HWI (SD) |
|---|---|---|
| All individuals | 0.47 (0.04) | 0.63 (0.08) |
| Female–female | 0.47 (0.05) | 0.60 (0.08) |
| Male–male | 0.49 (0.04) | 0.65 (0.07) |
| Female–male | 0.45 (0.04) | 0.57 (0.07) |

**Table 3** Number of dyads significantly different from random depending on sex classes; the total number of possible dyads is given for each dyad category

| | Fewer than expected ($P$<0.025) | More than expected ($P$>0.975) | Total number of possible dyads |
|---|---|---|---|
| Male–male | 52 | 40 | 210 |
| Female–female | 27 | 20 | 153 |
| Male–female | 120 | 12 | 378 |
| Totals | 202 | 74 | 780 |

From what we can infer from the tables and visual, we see that there are groups formed by creating trees relating to linkage, and that there are different dyads/partnerships being formed: male-male, female-female, and male-female, within the community.

## Network Analysis:

We analyze the network depending on various network factors such as degree centrality, betweenness centrality, community detection, etc. The network is connected, meaning every dolphin in the network is connected to other dolphins; no dolphin is isolated. The network is simple and doesn't contain any loops or multiple edges. The network is undirected and connected, therefore it can be termed as a weakly connected graph.

The graph below shows the gender distribution across the network. Out of the 62 dolphins, 33 are male dolphins (blue nodes), 25 are female dolphins (pink nodes) and 4 dolphins with unknown gender (white nodes).

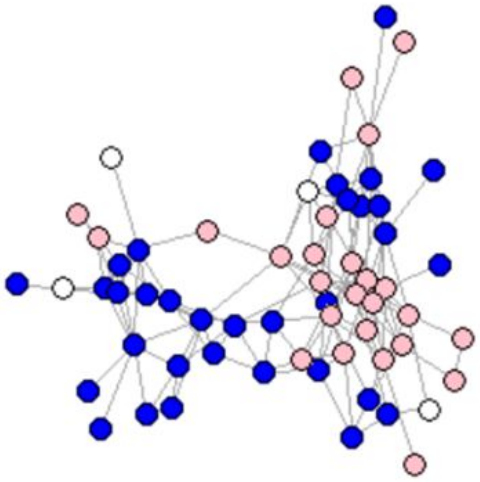


**Figure: Gender Distribution**

We can see that a large portion of connections are same sex connections; dolphins of the same gender interact with each other. The percentage of same sex edges in the network is 70.27%. Due to this high percentage of similar gender connection, in case of a disease outbreak, a certain gender may be affected more than other, which may lead to imbalance in the sex ratio.

The next step we have here is to plot different network layouts to understand the network better, and go over the different measures used to analyze our network. Here are a couple plots of the overall network, followed by each measure:

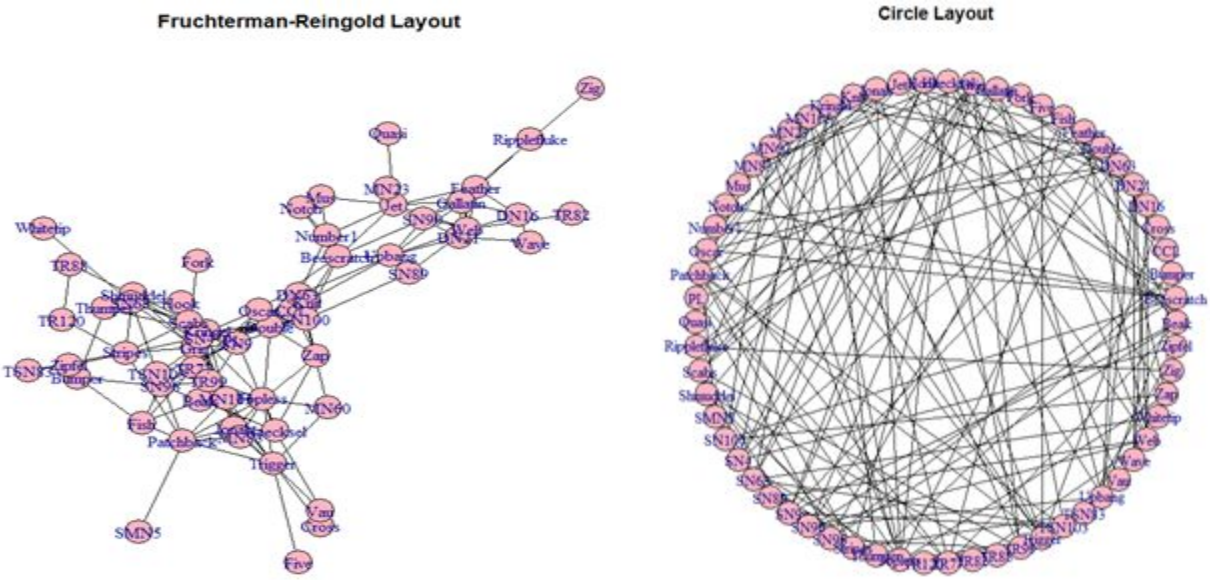



**Figure: Network Layouts**

**Degree Centrality:** We look at the degree distribution in the network. Degree centrality gives us the counts of the number of links held by each node. It helps in identifying the node that can swiftly connect with a larger network. The degree distribution for this network lies between 1 to 12.

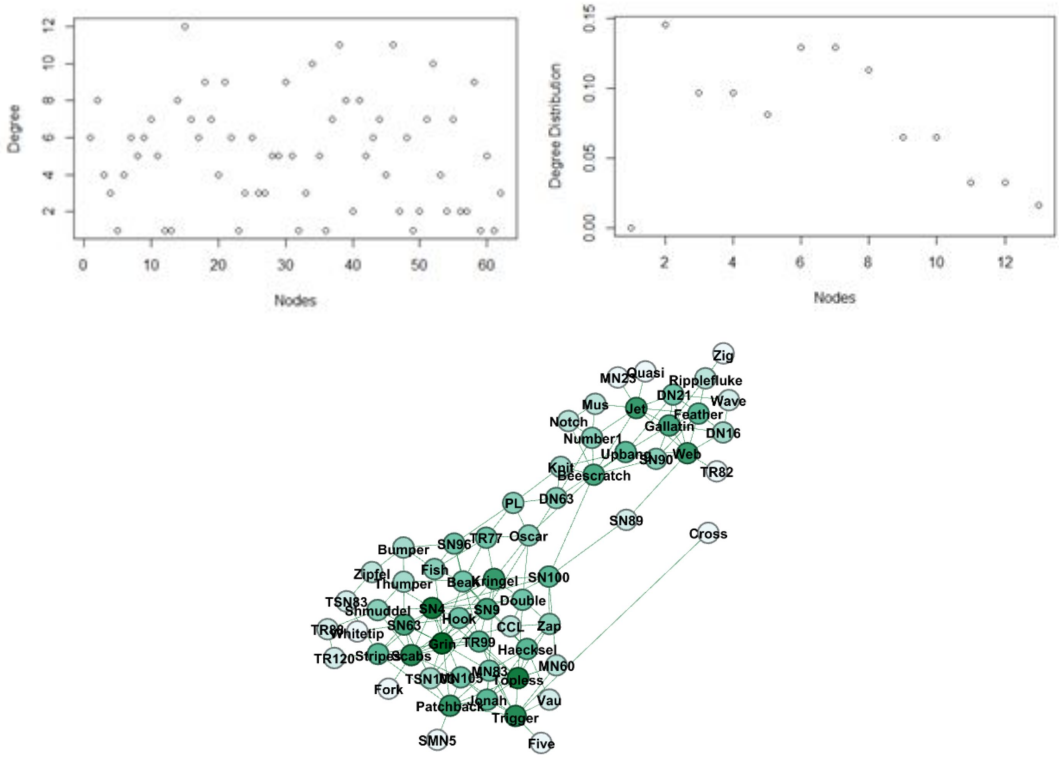



**Figure: Degree Distribution (the darker the node, the higher the value)**

For the network in consideration, a dolphin named Grin has the highest degree. That means Grin is the most social dolphin amongst the lot. The top 10 dolphins with the highest degree are plotted below.

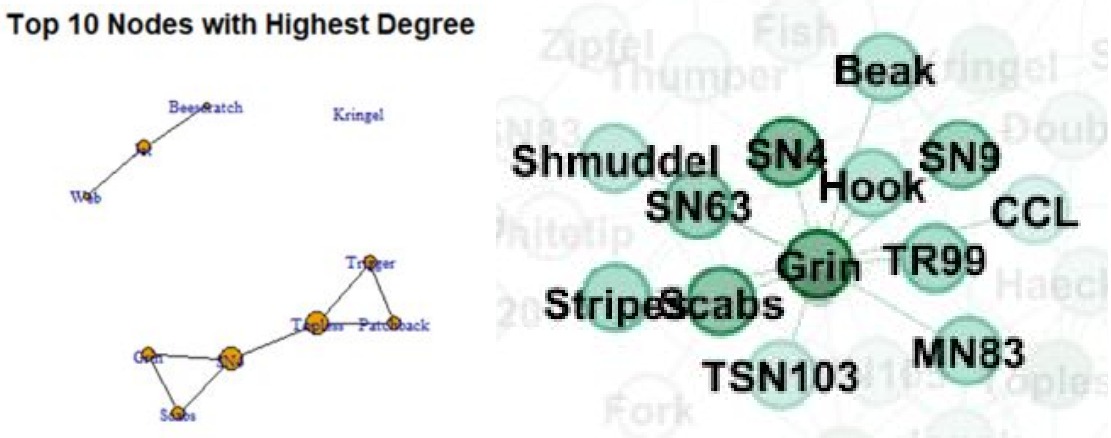


**Figure: Dolphin with Highest Degree**

**Closeness Centrality:** It takes into account the complete network. It is useful in finding the position of the most influential nodes in the network. Closeness centrality calculates the shortest path between nodes and assigns a score. The range of closeness centrality for the dolphin network is between 0.006849315 to 0.002923977 with dolphin named SN100 having the highest value of closeness centrality. Dolphin Grin which had the highest degree stands within the top 5 dolphins with highest closeness centrality.

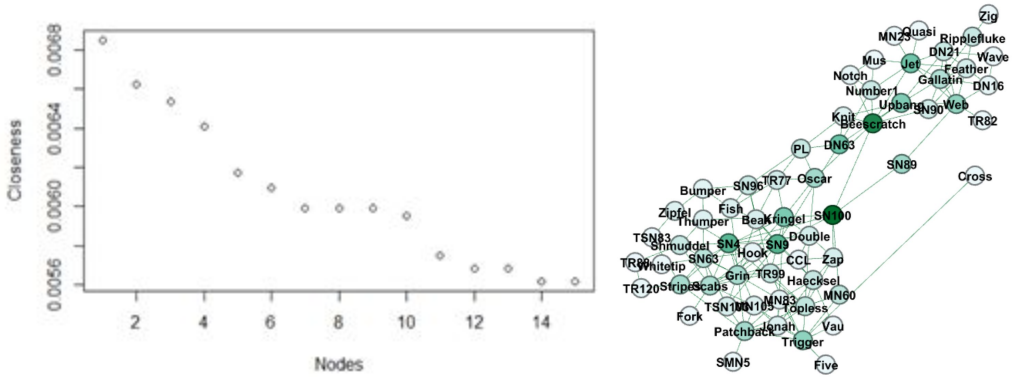



**Figure: Plot for Closeness Centrality (the darker the node, the higher the value)**

**Betweenness Centrality:** It captures how much a node is in between others. A node having higher betweenness is influential because more information will pass through that node. Betweenness centrality quantifies the number of times a node acts as a bridge. The betweenness centrality for the network in consideration ranges from 454 to 0. The dolphin with the highest betweenness is SN100. Following is the plot for the top 10 dolphins with highest betweenness.

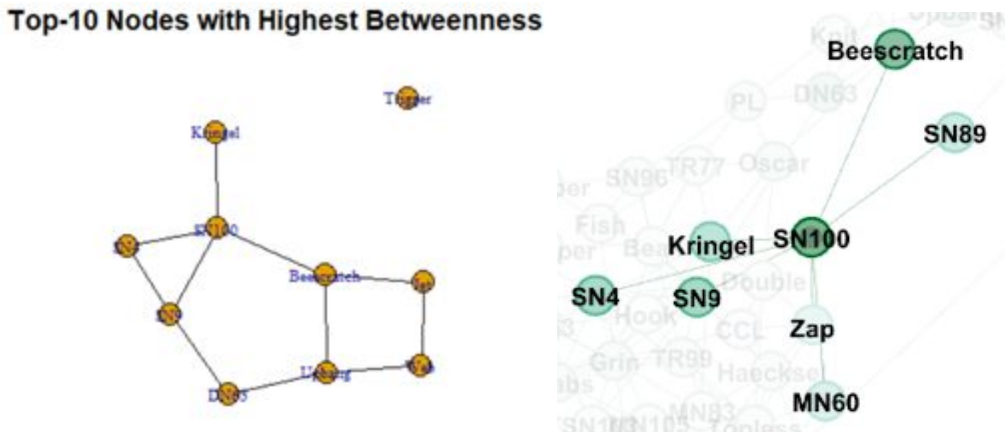



**Figure: Dolphins with highest betweenness**

**Eigen Centrality:** It takes into account the number of neighbors of the node in consideration and also the caliber of connection. If the node in consideration is connected to a high scoring node, the score of the node in consideration also increases. The dolphins Grin, SN4 and Topless have the highest eigen centralities in the network.

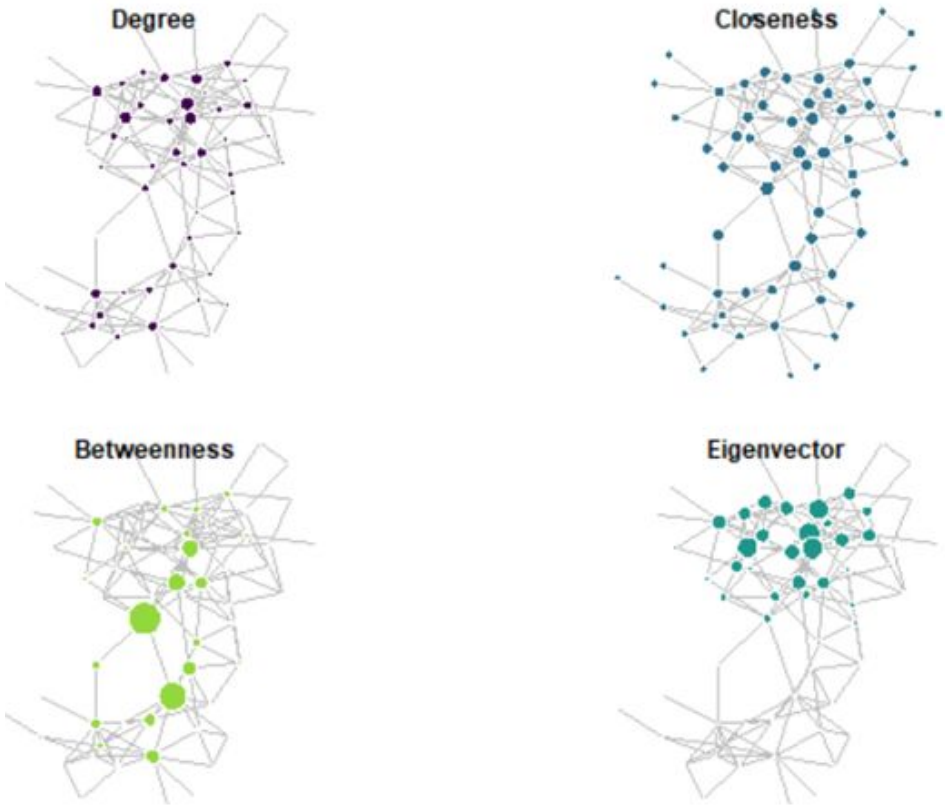
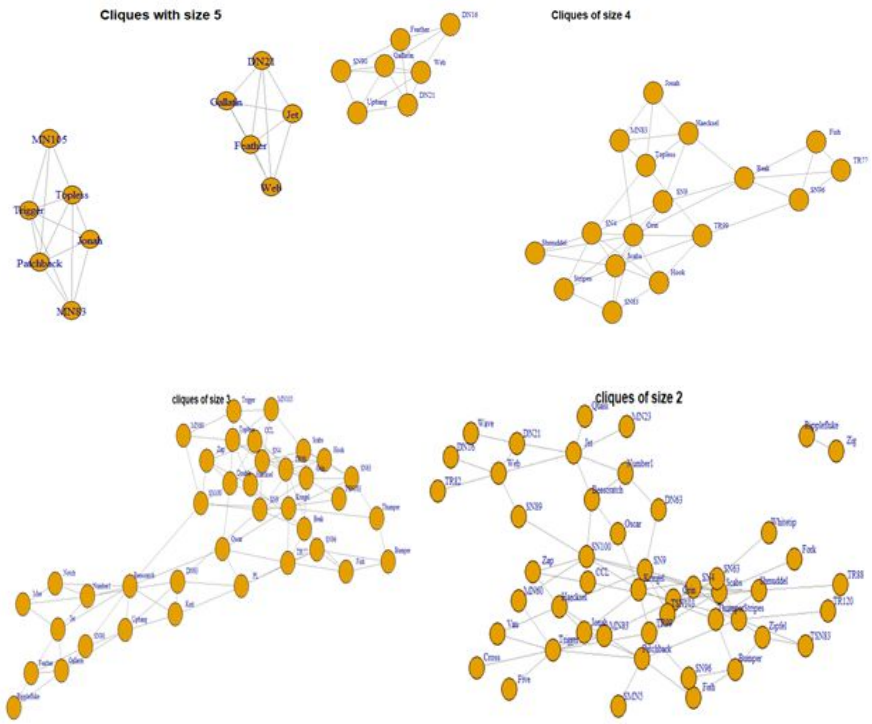



**Figure: Centrality Plots**

**Transitivity:** For this network, the transitivity is 0.3087757. That means we will find common nodes across the network. It gives us the degree to which the dolphins in the network will form groups. In our network, the dolphins are linked and we expect to see many groups and clusters since the transitivity of the network is high.

**Average Path Length and Diameter:** The average path length for this network is 3.356954 that means it takes approximately 4 steps for information to reach from one dolphin to another. The diameter of the network is 8 when edge weights are considered and is 11.54156 when inverse edge weights are considered.

**Cliques:** We identified cliques for the network. It shows a group of dolphins where every dolphin is directly connected to every other dolphin. We identified 3 cliques of size 5, 13 cliques of size 4, 30 cliques of size 3 and 38 cliques of size 2.




**Community Detection:** Much like humans, dolphins are social animals and form complex dynamic networks. The information about community and social networks of dolphins can be used to analyze their behavioural patterns, breeding patterns and disease transmission in a network. We ran the 3 community detection algorithms namely Fast-Greedy Algorithm, Girvan Newman Algorithm and Walk-Trap algorithm. Prominently there are 4 communities in the dolphin network with a slight overlap between some of them.

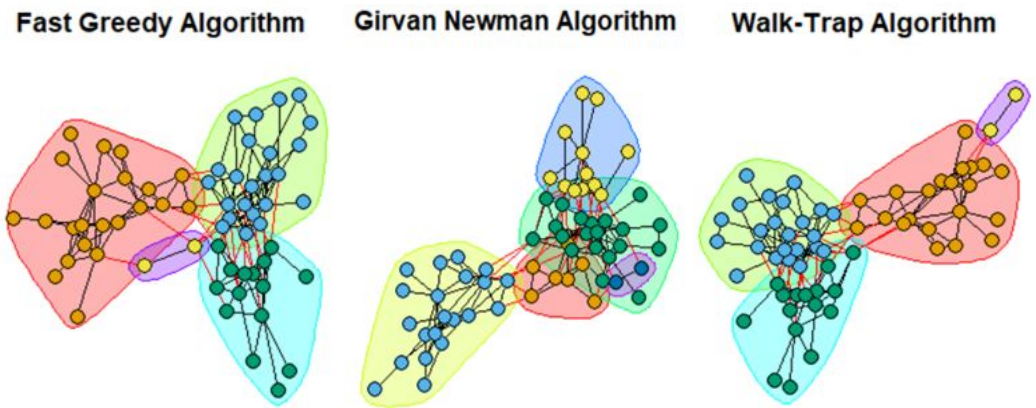



**Figure: Community Detection Algorithm Plots**

**Structural Holes:** The concept put forward by Ronald Brut suggests that some nodes in a network act as bridges between groups in the network by transferring information from one group to another. These nodes may also combine information coming from different groups and create novel information. We plotted 20 dolphins with the highest structural holes, and can see that dolphins SN100 and Beescratch act as bridges between the two groups in the network.

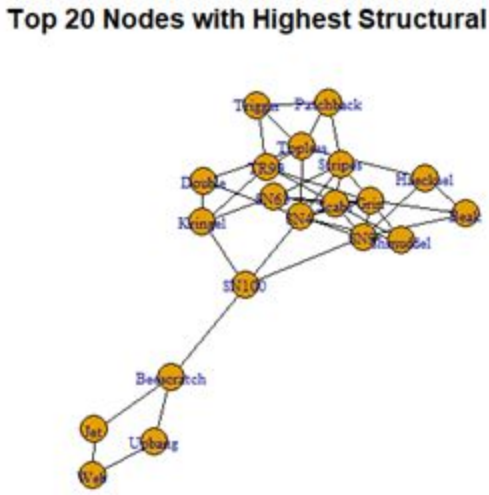



**Figure: Structural Holes**

When we plot a graph between average clustering vs degree of the nodes in the network, we can see a negative relationship between them. It makes sense to have a negative relationship between them because dolphins belonging to the same cluster will have high clustering coefficient but low degree as dolphins in the cluster will not be connected to dolphins outside the cluster. When we take a look at betweenness vs degree, we see a positive relationship between them. This is quite logical because both degree and betweenness are related to interaction and transfer of information.

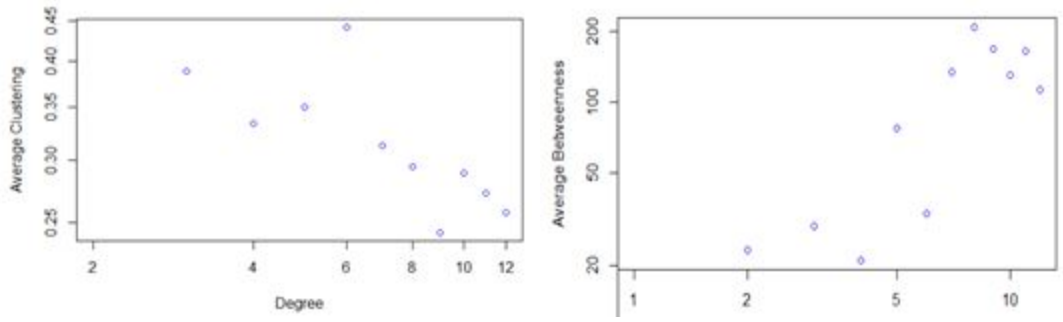



**Figure: Plots of Clustering and Betweenness vs Degree**

The relationship between average constraint and degree is negative. A dolphin with high degree will have low embeddedness, the same can be seen in the plot. When we plot a graph of average

betweenness and clustering, we see a negative relationship. This goes with the concept that dolphins with high average betweenness will have low clustering value. Hence the negative relationship is justified.

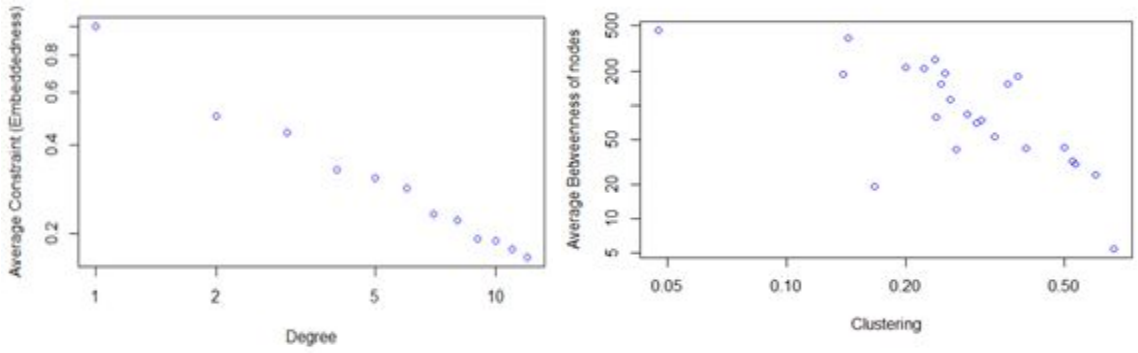



**Figure: Plots of constraint vs degree and betweenness vs clustering**

## Final Insights and Conclusions:

So what can we take away from this community given the measures we described above?

Well, one finding that we notice is that even though the network is undirected, multiple connections can be formed pretty easily: a network transitivity value of 0.3087757 further demonstrates this point. This makes sense because dolphins can form groups, cliques, and relationships since they're not only social beings, but they travel around in the water close to each other all the time.

Another observation we can make is that certain dolphins play an important part in the community. For example, dolphin SN100 is noted to have the highest betweenness of the bunch and is seen to be a key part in being a bridge between a couple big groups in the network. This dolphin could possibly be a messenger for other dolphins that shares information between these two groups just like we would as people. Another example is Grin; Grin is observed to be the most social dolphin in the community with the highest degree sitting at 12. This dolphin also has a closeness centrality value of 0.3765; to put this into context, it's the 5th most out of the 62 dolphins in the network. An assumption we can make here right away is that this guy is a leader within the community communicating with other dolphins, interacting with most of them, and possibly even directing everyone through its actions in the water. We can compare this to a person of upper management over at a company; this person interacts with a lot of people, leads a team, and is an important part of the company. Maybe Grin is this leader of the dolphin network that acts in this way.

One last finding that we can work on in the near future is predicting and simulating what happens when a disease strikes the community of dolphins. Does the disease get spread at a fast rate? Will a certain gender get more affected than the other? This would be very interesting to see and scope out in the future, since each dolphin is so close to one another and they all interact with each other all the time. The assumption is that since they're so close to each other, the disease would spread quickly, and that a certain gender would be affected more than the other because of the amount of partnerships that are present within the network. If one dolphin gets infected, chances are the respective partner also gets infected, and this could happen for either gender.

So where can these findings be **useful**? Well, according to The article "*Identifying the role that individual animals play in their social network*, they sure can: "...the analysis of animal social networks can offer substantial insights into the social dynamics of animal populations and possibly suggest new management strategies". Not only can we gain another perspective on different types of animals living together, we can also learn a thing or two in the corporate world. We can learn a lot from Grin for instance; a general manager can have a lot of power from having a close relationship with the employees he/she works with, great communication skills, and interacting continuously to make sure everyone's on the same page. In terms of the **audience** that can get a kick out of the finds that we see, we think that all types of people can find use out of them. Whether you're a teacher, manager, student, or just a regular person, we can all learn from the way dolphins interact with each other. That's the beauty of learning, and studying social networks; we can all learn from each other.

**Bibliography:**

Lusseau D., Schneider K., Boisseau O.J., Haase P., Slooten E. & Dawson S.M. (2003) The bottlenose dolphin community of Doubtful Sound features a large proportion of long-lasting associations - Can geographic isolation explain this unique trait? Behavioral Ecology and Sociobiology, 54, 396-405.

Lusseau David and Newman M. E. J. 2004 Identifying the role that animals play in their social networks Proc. R. Soc. Lond. B.271S477–S481 http://doi.org/10.1098/rsbl.2004.0225