DOLPHIN SOCIAL NETWORK ANALYSIS AND VISUALIZATION

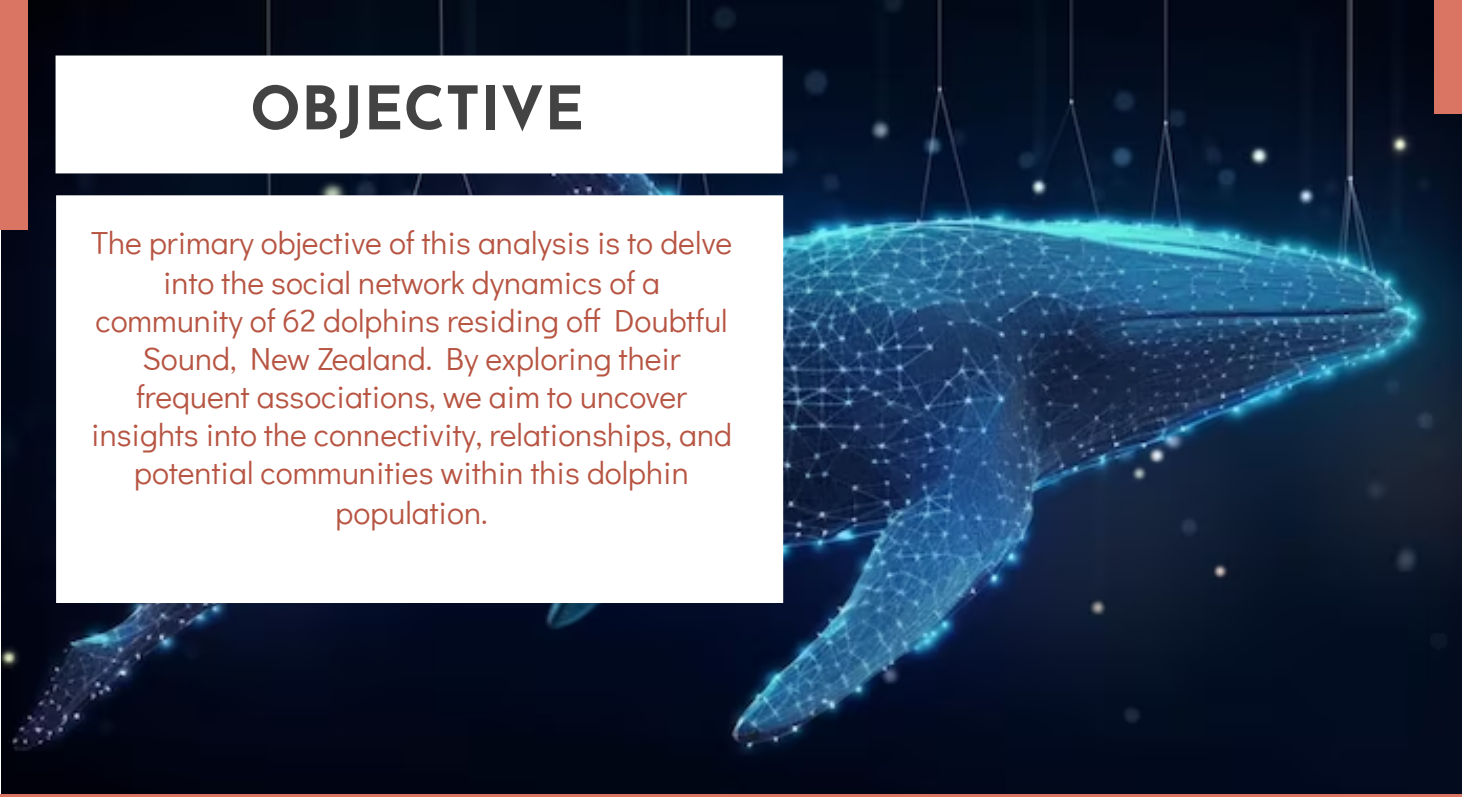
A Project by Konstantinos Soufleros

INTRODUCTION

In the realm of ecological studies, understanding the intricate relationships within animal communities is paramount. One captivating example of such interactions is the dolphin social network. Dolphins, as highly social creatures, exhibit patterns of association that can shed light on their social structures and behaviors.

OBJECTIVE

The primary objective of this analysis is to delve into the social network dynamics of a community of 62 dolphins residing off Doubtful Sound, New Zealand. By exploring their frequent associations, we aim to uncover insights into the connectivity, relationships, and potential communities within this dolphin population.



RESEARCH QUESTION

"How do dolphins form associations and interact within their community, and what insights can these interactions provide about their social dynamics?"

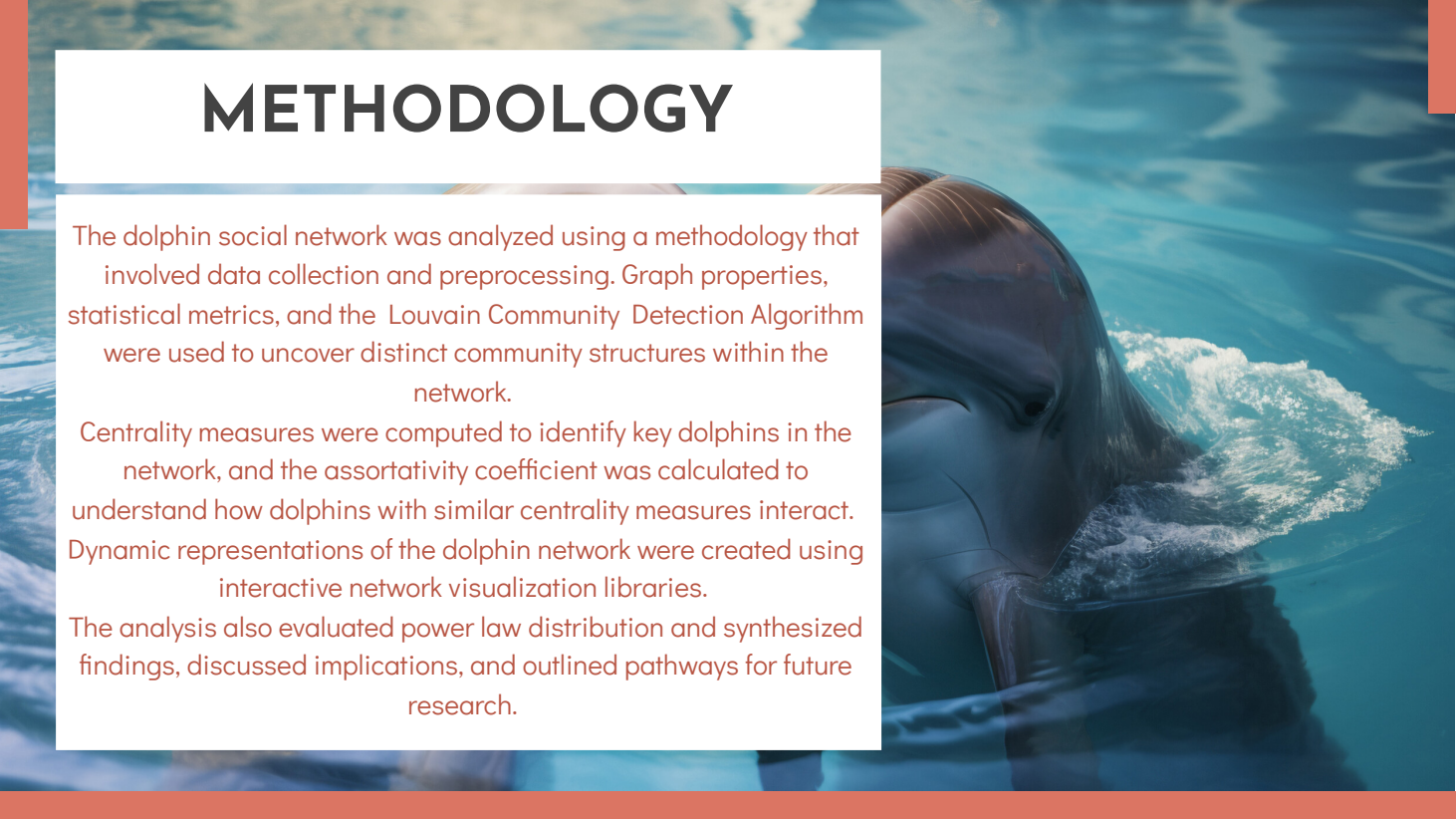
METHODOLOGY

The dolphin social network was analyzed using a methodology that involved data collection and preprocessing. Graph properties, statistical metrics, and the Louvain Community Detection Algorithm were used to uncover distinct community structures within the network.

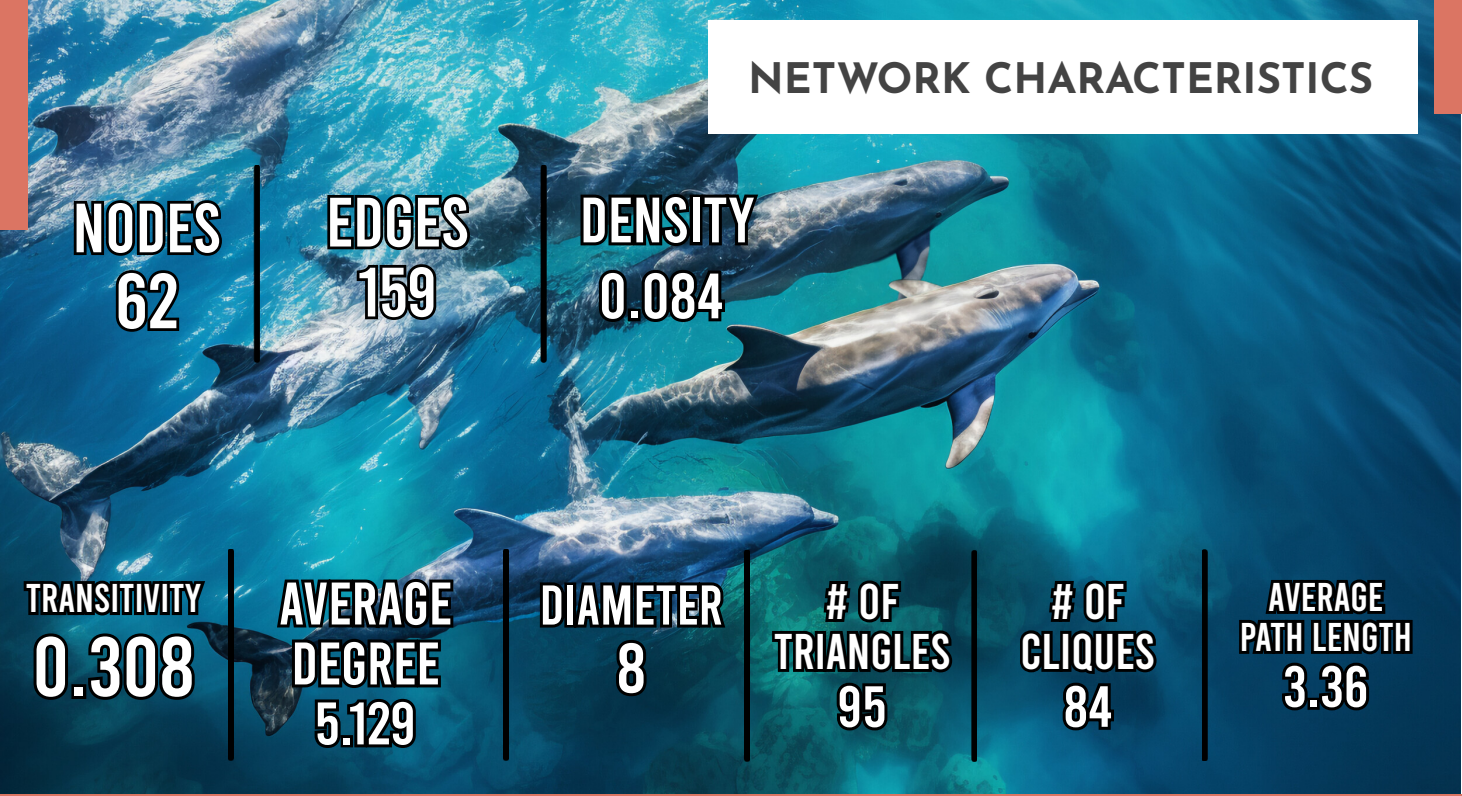
Centrality measures were computed to identify key dolphins in the network, and the assortativity coefficient was calculated to understand how dolphins with similar centrality measures interact.

Dynamic representations of the dolphin network were created using interactive network visualization libraries.

The analysis also evaluated power law distribution and synthesized findings, discussed implications, and outlined pathways for future research.



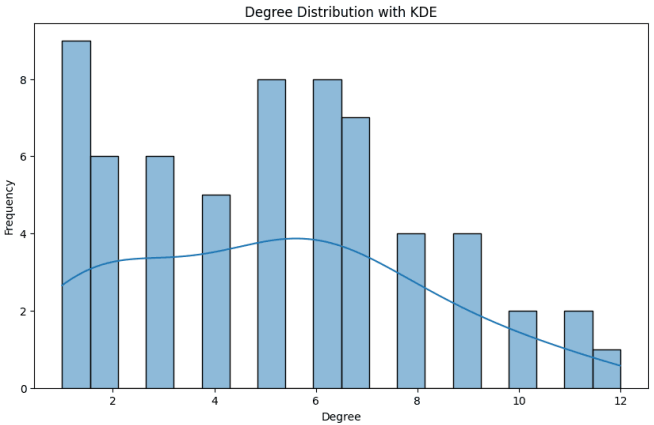
NETWORK CHARACTERISTICS

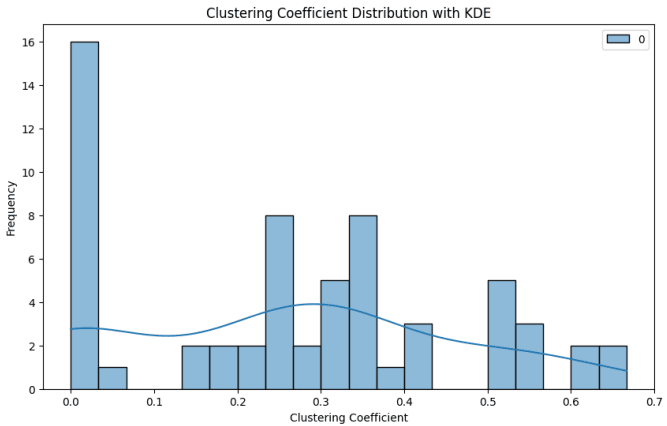


NODES	EDGES	DENSITY
62	159	0.084

TRANSITIVITY	AVERAGE DEGREE	DIAMETER	# OF TRIANGLES	# OF CLIQUES	AVERAGE PATH LENGTH
0.308	5.129	8	95	84	3.36

NETWORK CHARACTERISTICS

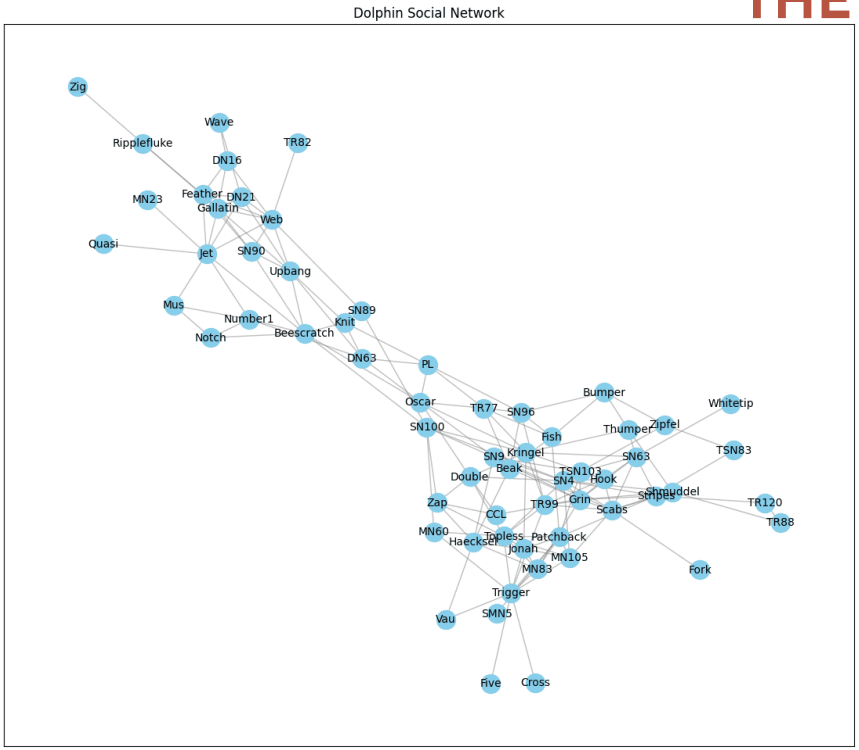




The degree distribution plot provides insights into the structure of the network and the distribution of node importance or connectivity. The clustering coefficient distribution gives insights into how tightly connected nodes are in the network.

THE NETWORK

Our nodes (dolphins) and their interactions (edges).

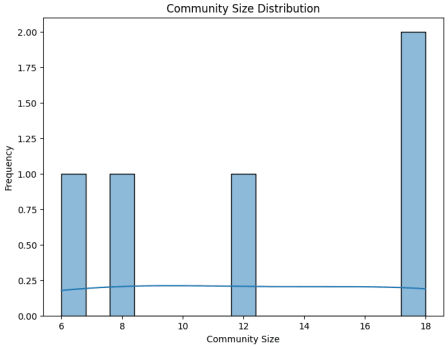


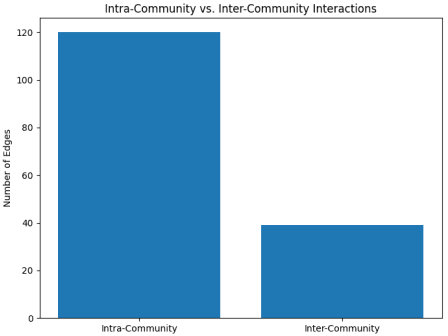
COMMUNITY DETECTION

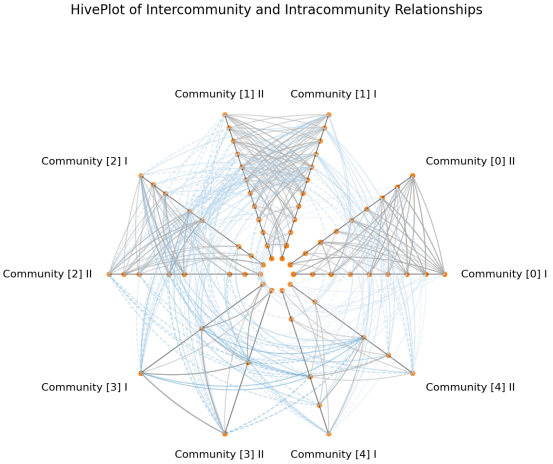
The Louvain algorithm is a popular method for detecting communities or clusters within networks by optimizing a modularity score. Each community consists of nodes that are densely connected to each other and have fewer connections to nodes outside the community.

The identification of 5 communities within the dolphin social network suggests that there are distinct groups of dolphins that interact more closely with each other compared to dolphins outside their respective communities.

COMMUNITY CHARACTERISTICS

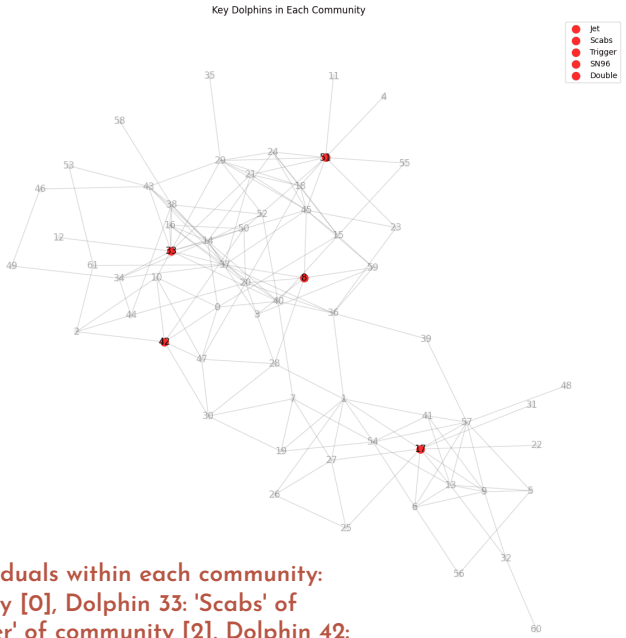






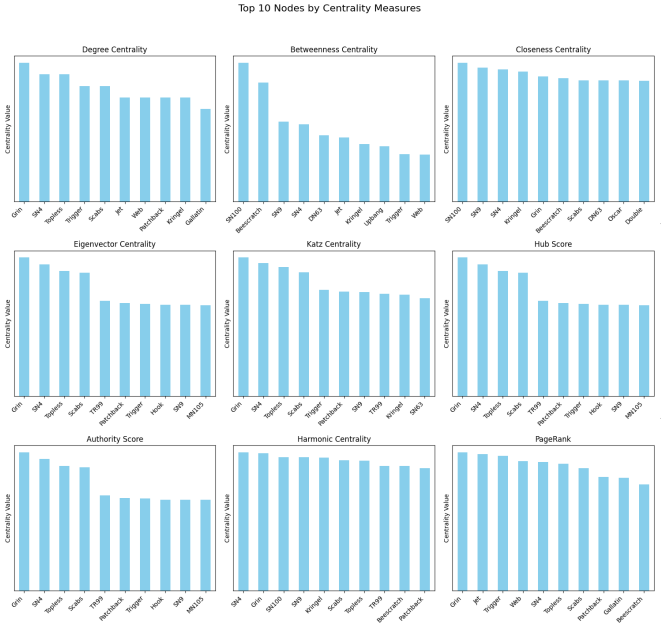
There is even distribution of community sizes and that suggests a balanced distribution of dolphins across different communities. The larger number of intra-community interactions suggests that dolphins within the same community tend to interact more frequently with each other. The hiveplot shows in 'darkgrey' the interactions inside each community and the blue lines are the interactions outside the community. Community [0], [1], [2] have more dense intra-relationships and Community [3] and [4] have more inter-relationships.

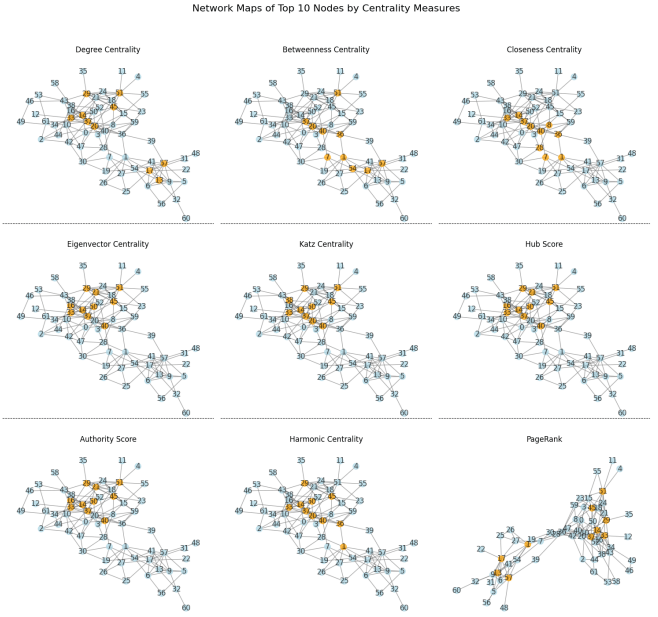
IDENTIFYING KEY DOLPHINS



These are the influential individuals within each community: Dolphin 17: 'Jet' of community [0], Dolphin 33: 'Scabs' of community [1], Dolphin 51: 'Trigger' of community [2], Dolphin 42: 'SN96' of community [3], Dolphin 8: 'Double' of community [4]

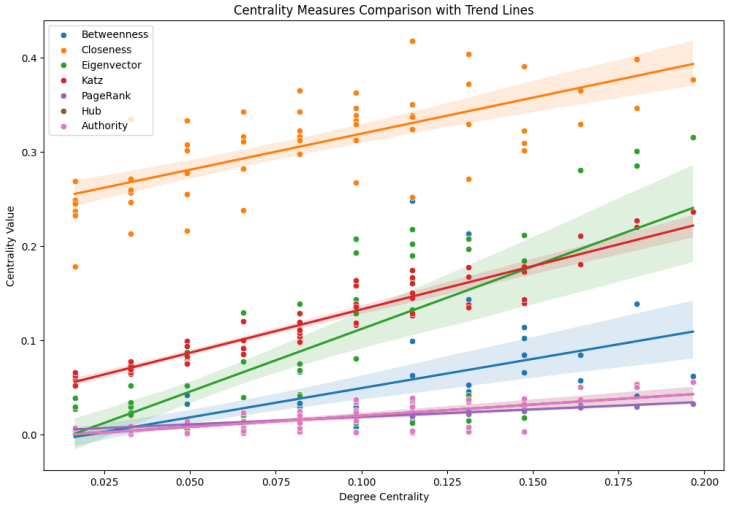
CENTRALITY MEASURES

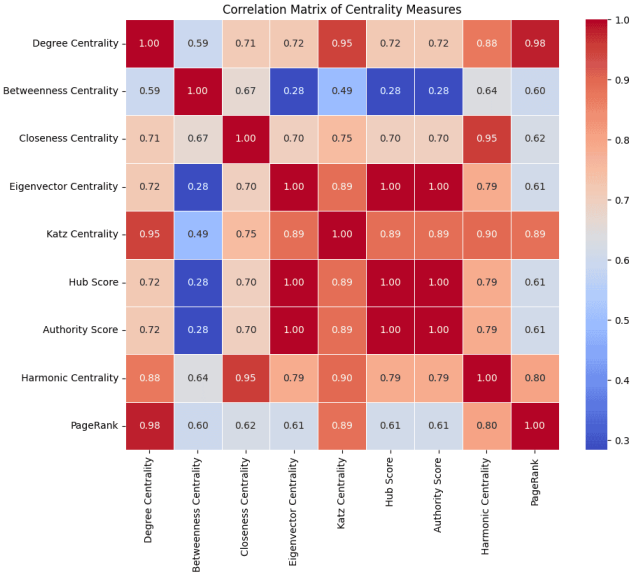




We identified the top 10 nodes by each centrality measure and visualized them in the network.

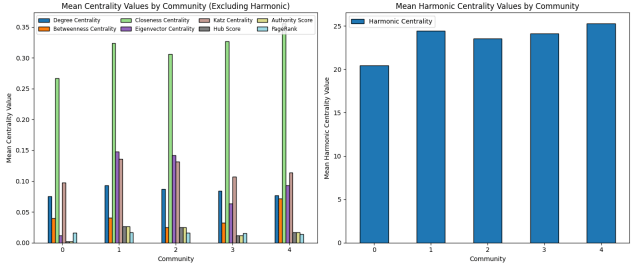
MEASURES COMPARISON & CORRELATION

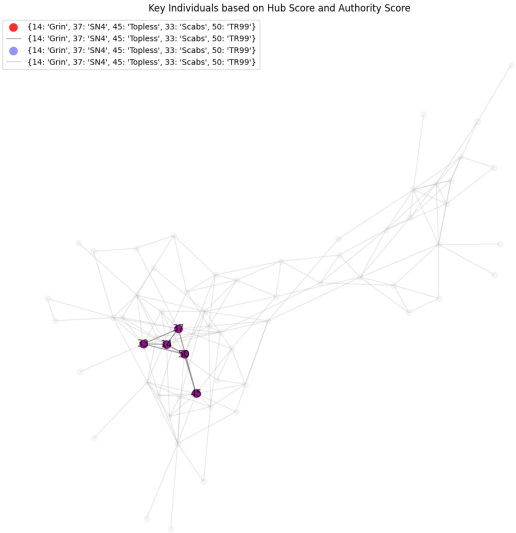




We visualized centrality measures using scatter plots and also calculated the correlations between the different centrality measures.

COMMUNITY COMPOSITION AND SOCIAL ROLES

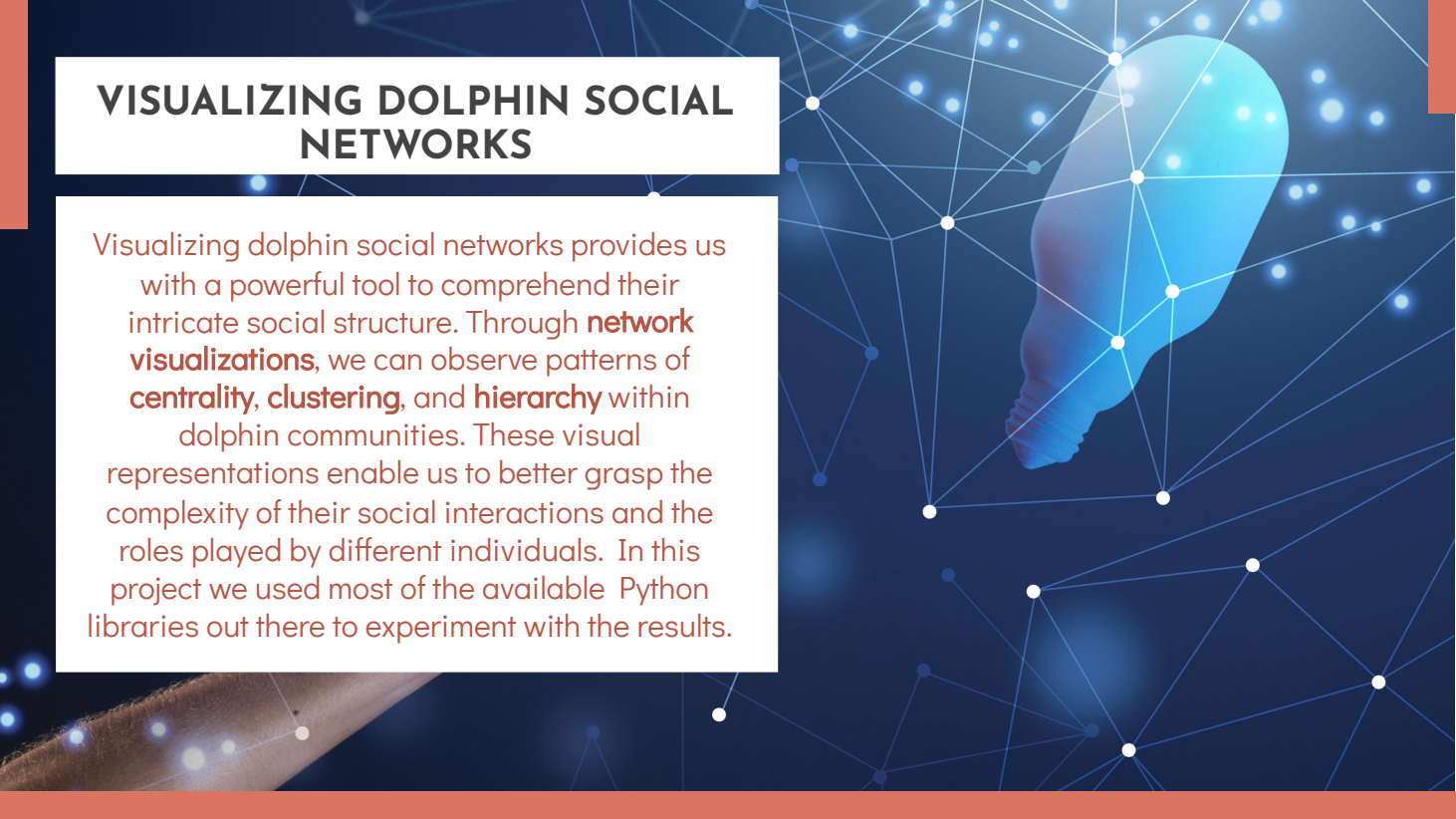




The differences in centrality values across communities suggest that certain communities might have specific nodes that act as connectors, influencers, or central points of communication.
Then we used centrality measures like "Hub Score" and "Authority Score" to identify nodes that play central and influential roles.
The top 5 nodes with the highest Hub Score and Authority Score are the same:Node 14: 'Grin', Node 37: 'SN4', Node 45: 'Topless', Node 33: 'Scabs', Node 50: 'TR99'

VISUALIZING DOLPHIN SOCIAL NETWORKS

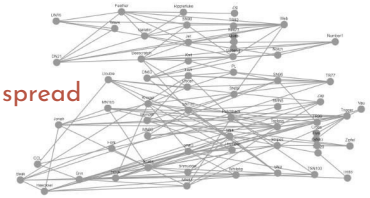
Visualizing dolphin social networks provides us with a powerful tool to comprehend their intricate social structure. Through **network visualizations**, we can observe patterns of **centrality**, **clustering**, and **hierarchy** within dolphin communities. These visual representations enable us to better grasp the complexity of their social interactions and the roles played by different individuals. In this project we used most of the available Python libraries out there to experiment with the results.



NETWORK VISUALIZATIONS


euler


klay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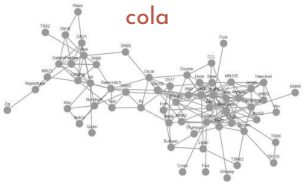
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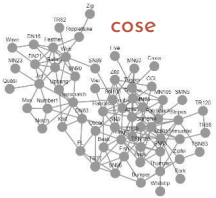
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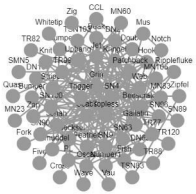
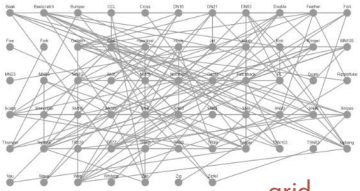
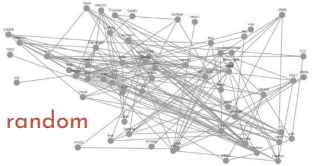

concentric

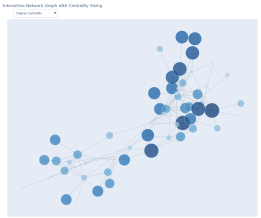
These are the visualizations we created with Cytoscape and Dash using different layout options to explore the network from various perspectives. This enables insights into the structure and connections within the dolphin social network.

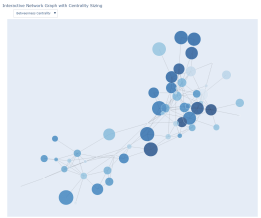

breadthfirst

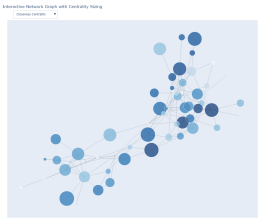

grid

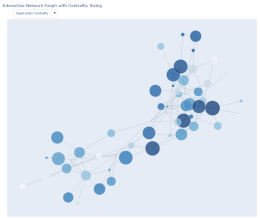

random

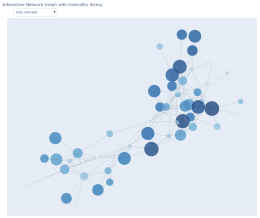
NETWORK VISUALIZATIONS

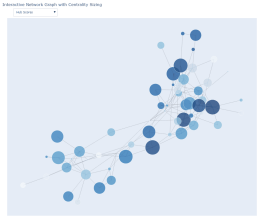


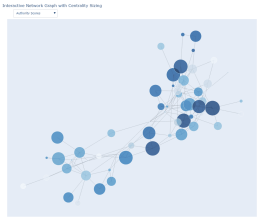


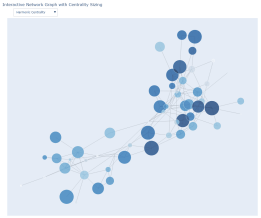


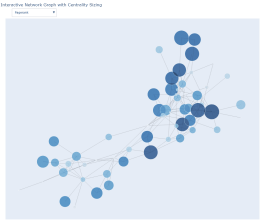






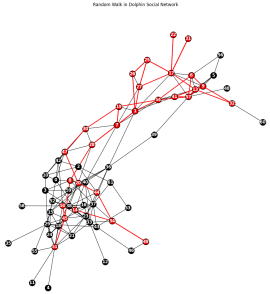


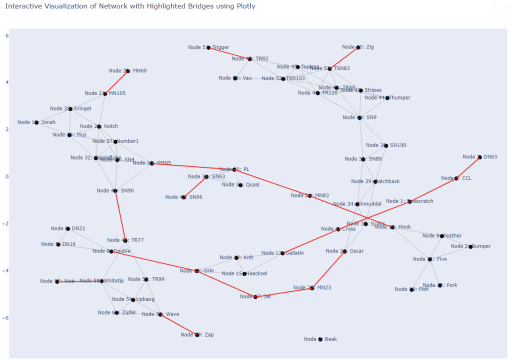




We utilized Plotly to generate network plots, where node size was determined based on their respective centrality measure. For each of the nine centrality measures used, we created a separate network plot. Another interesting plot with Plotly below is with node coloring according to the number of connections with other nodes.

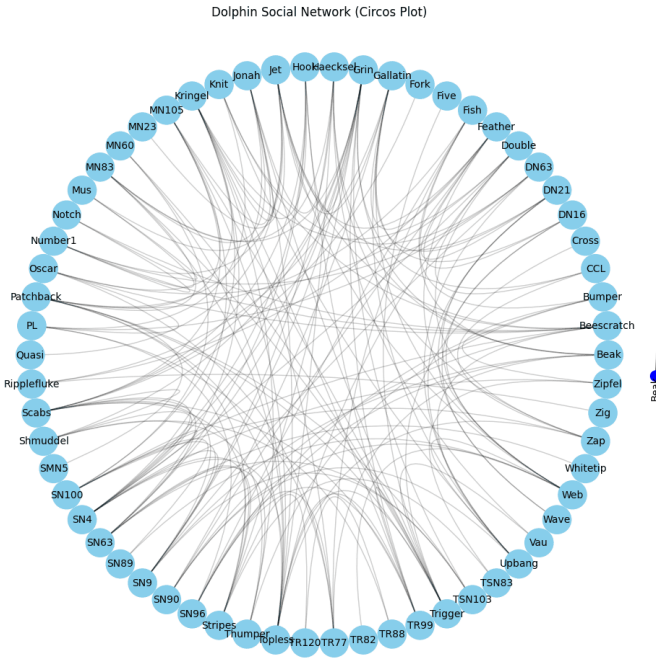
NETWORK VISUALIZATIONS

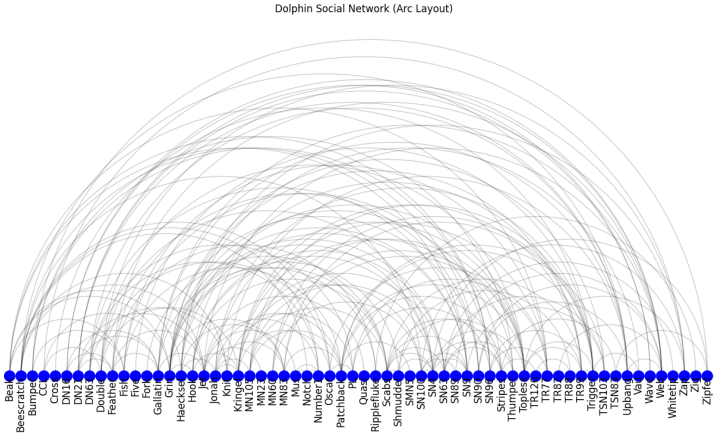




We used igraph to focus on four-dolphin cliques, tightly connected groups within the larger dolphin community. These cliques were highlighted in yellow with red lines connecting them. We chose four-node cliques for their balance between group dynamics and visual clarity. We created a random walk plot with igraph and networkx to observe information or interaction spread through the network. In the last plot of igraph with Plotly we identified key nodes and relationships that maintain network cohesion by highlighting bridges, edges that disconnect the network into multiple components when removed.

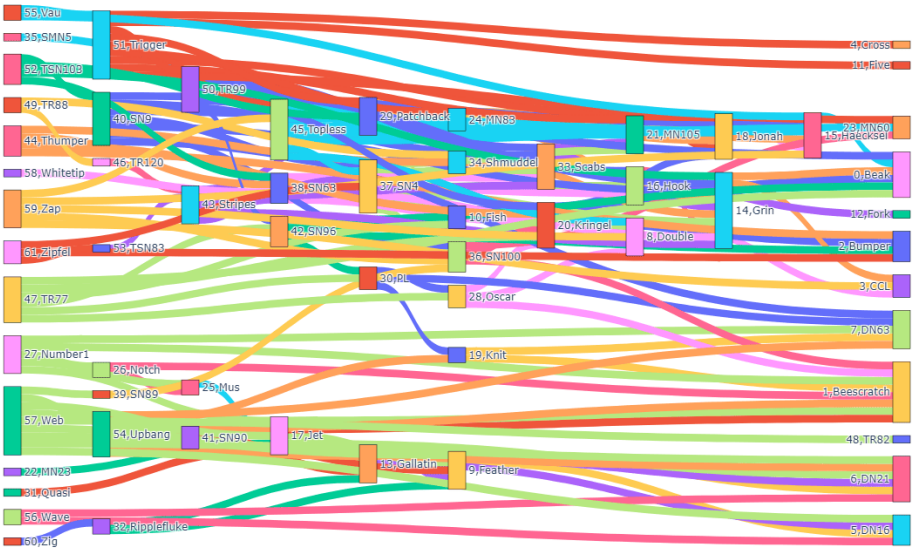
NETWORK VISUALIZATIONS



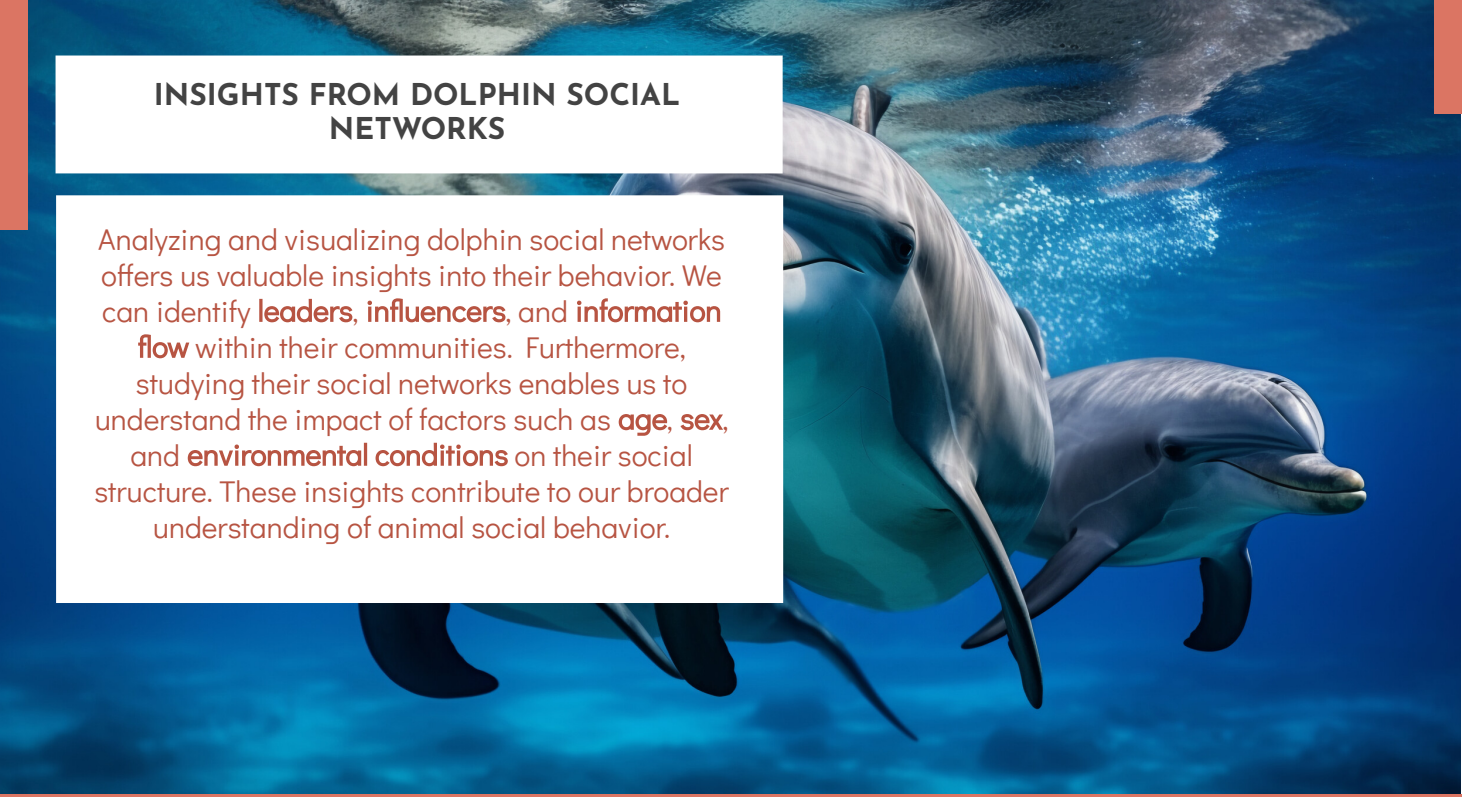


With the use of the nxviz library we employed Circos plot to portray interactions between dolphins in a circular layout, highlighting their connections within and between communities. Additionally, Arc plot helped us to understand the flow of the network by providing a visual representation of directed interactions.

NETWORK VISUALIZATIONS



We used the Dash framework to create an interactive Sankey plot that illustrates the flow of interactions among dolphins. This allows us to explore the details, hover over nodes to reveal individual relationships, and gain a deeper understanding of the network's complexity.



INSIGHTS FROM DOLPHIN SOCIAL NETWORKS

Analyzing and visualizing dolphin social networks offers us valuable insights into their behavior. We can identify **leaders**, **influencers**, and **information flow** within their communities. Furthermore, studying their social networks enables us to understand the impact of factors such as **age**, **sex**, and **environmental conditions** on their social structure. These insights contribute to our broader understanding of animal social behavior.

SUMMARY OF FINDINGS

The dolphin social network consists of 62 nodes and 159 edges, with an average degree of 5.13.

The network is not overly dense but has clusters or communities.

There are 5 distinct communities, with varying sizes and potential roles.

Key dolphins act as influential individuals, maintaining community stability.

Different centrality measures provide insights into individual importance.

Dolphins with different degrees are more likely to connect, indicating a diverse social structure.

The degree distribution suggests a Log-Normal distribution for social connections among dolphins.

RECOMMENDATIONS

Further research could explore various avenues to enhance our understanding:

1. **Longitudinal Studies**: Conducting longitudinal studies over extended periods could reveal temporal changes in the network, shedding light on the stability and dynamics of dolphin communities.
2. **Behavioral Observations**: Linking network data with behavioral observations could provide insights into the functions of different communities, their roles, and how interactions contribute to survival and reproduction.
3. **Environmental Factors**: Investigate how external factors such as food availability, climate, and human activities influence the formation and dynamics of dolphin communities.
4. **Multimodal Data Integration**: Combine network data with other data sources like genetic information, vocalizations, and geographic positioning to provide a holistic view of dolphin interactions.
5. **Comparative Studies**: Compare dolphin social networks with other species' networks to understand commonalities and differences in social organization across marine and terrestrial ecosystems.

CONCLUSION

In conclusion, our analysis of the dolphin social network has provided valuable insights into the structure, interactions, and centrality of dolphins within their communities. Through various network characteristics and visualization techniques, we have gained a comprehensive understanding of how dolphins form distinct communities and the significance of key individuals within these communities.

Thanks!

Do you have any questions?

soufleros.kostas@gmail.com
+381 612 979 469

 https://github.com/kostas696

 https://www.linkedin.com/in/konstantinos-soufleros/