NETWORK ANALYSIS OF THE HAWAI‘I-BASED LONGLINE FISHERY

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HAWAI‘I DEEP-SET LONGLINE FISHERY

TARGETS BIGEYE TUNA BUT RETAINS AND SELLS OTHER SPECIES

8TH LARGEST BY VALUE IN THE US

FOOTPRINT OF 15 MILLION KM²

SPATIAL SHIFT OF THE FISHERY TOWARDS THE NORTH EAST
CPUE
1994 - 2018

OBSERVER DATA
CPUE

1994-2018

OBSERVER DATA

**Bigeye has relatively even distribution of CPUE across the fishery**
THE SAME IS NOT TRUE FOR OTHER SPECIES

DISTINCT SPATIAL PATTERNS IN CPUE
**Management Challenges**

**Bigeye** is the only managed species being fished and annual quotas are set by RFMOs.

Fishery experiences closures due to protected species interactions.

Can understanding species associations and networks in fisheries dependent catch data inform EBFM?
Management Challenges

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CO-OCCURRENCE AND NETWORK ANALYSIS

**CO-OCCURRENCE**
- Pairwise
- Greater or less than random chance

**CLUSTERING**
- Optimal modality
- Possible because networks are small

**NETWORKS**
- Undirected
- Positive and non-random

**CENTRALITY MEASURES**
- Degree
- Closeness
- Betweenness
Network Analysis

Co-occurrence

Clustering

Networks

Centrality Measures

Pairwise

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All years individually and aggregate

For top 46 species

Over four spatial regions

Centrality measures

Degree

Closeness

Betweenness
Pairwise Co-occurrence

Species that occur more or less often than by random chance

Cooccur package in R
PAIRWISE CO-OCCURRENCE

2018

Pelagic Thresher Shark
Oceanic Whitetip Shark
Great Barracuda
Opah
Velvet Dogfish
Striped Marlin
Lanceletfish
Mahimahi
Snake Mackerel
Shortfin Mako
Swordfish
Bluefin Tuna
Wahoo
Shortbill Spearfish
Escolar
Yellowfin Tuna

More Often
Random Chance
Less Often
Pairwise Co-occurrence

2018
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CENRALITY MEASURES

Degree centrality
- Number of interactions
  - Local

Closeness centrality
- Proximity to all other species
  - Global
  - How rapidly influences the network

Betweenness centrality
- How many paths go through node
  - Influence of species loss on fragmentation
Low degree and high closeness means the species has a key role by interacting with important species.
LOW DEGREE AND HIGH CLOSENESS MEANS BIGEYE HAS A KEY ROLE BY INTERACTING WITH IMPORTANT SPECIES

LOW DEGREE AND HIGH BETWEENNESS MEANS BIGEYE PLAYS A KEY ROLE IN CONNECTING SPECIES THAT WOULD OTHERWISE NOT BE CONNECTED
DEGREE CENTRALITY

BEST TO COMPARE CENTRALITY MEASURES ACROSS NETWORKS

$C_D$ QUANTIFIES THE IMMEDIATE INFLUENCE BETWEEN NODES

$C_D$ IN THE SOUTH WEST REGION IS STEADY WHILE NW AND CW REGIONS ARE INCREASING

➡️ MORE COMPLEX NETWORKS WITH TIME IN NW AND CW
How Can Networks Inform EBFM?

Include environmental variables in the co-occurrence analyses

Better guide fishers where to fish to increase commercially valuable catch and decrease discards

Would love input from you all on the management application of co-occurrence and network analysis!
THANK YOU!