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Prioritizing seagrass meadows for biodiversity conservation based on landscape connectivity

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Prioritizing seagrass meadows for biodiversity conservation based on landscape connectivity

John Cristiani
Mary O’Connor

Marine Geospatial Ecology Tools – Jason Roberts
UBC Salish Sea Project – Susan Allen
Conserving seagrass epifaunal biodiversity requires thinking at local and regional scales.

What’s currently missing at the regional level is an understanding of connectivity and a knowledge of at which scale communities are actually connected.

Photos: Emily Adamczyk
Understanding the scale at which communities are connected is important for management.

Decisions are made at regional levels.

Threats to habitat may have regional consequences.

*What happens if we remove one meadow? How does this affect the neighboring meadows and the biodiversity of the region?*

Need to think at a metacommunity level.
Regional diversity requires dispersal between local patches

Dispersal determined by:
- ocean currents
- life history traits

Marine metacommunity:
Nodes of distinct habitat connected by dispersal

Connections vary, and therefore some groups of meadows may be more “central” and important than others.
Are certain meadows more important than others for maintaining connectivity?

Can we use network theory as a tool to identify and protect important groups of meadows?

Are seagrass meadows connected by passive dispersal?

Regional level

Local patch level
Simulate dispersal with particle tracking

Follow invertebrates as they move in ocean currents across the seascape
See if they settle on other seagrass patches

Movement affected by:
- ocean currents
- mortality

Passive surface dispersal

Spatial resolution: 436 meters
Temporal resolution: 1 hour
Simulate dispersal with particle tracking

\[ \frac{\partial N}{\partial t} = -u \frac{\partial N}{\partial x} - v \frac{\partial N}{\partial y} + K \left( \frac{\partial^2 N}{\partial x^2} + \frac{\partial^2 N}{\partial y^2} \right) - \mu N \]

Concentration = Advection + Diffusion - Mortality

Treml et al. 2008

Spatial resolution: 436 meters
Temporal resolution: 1 hour

UBC Salish Sea Project
Marine Geospatial Ecology Tools
Simulate dispersal with particle tracking

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Concentration = Advection + Diffusion - Mortality

Treml et al. 2008

Baseline Parameters:

- 15% daily mortality rate
- Simulation runs for 7 days

Timing of scenarios to capture variation by:

- Season
- Two week tidal cycle
- Daily tidal cycle

Spatial resolution: 436 meters
Temporal resolution: 1 hour

UBC Salish Sea Project
Marine Geospatial Ecology Tools
Track densities of particles to determine where inverts are likely to disperse
Establish connections based on a minimum threshold of particles settling at a distant patch.
Using network analysis and connectivity metrics to identify important meadows

Node removal to measure importance

Change in overall graph connectivity ($dPC$):
The change in the sum of the product probability of all paths between all nodes
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$PC = 6.53$
Using network analysis and connectivity metrics to identify important meadows.

Node removal to measure importance

Change in overall graph connectivity ($dPC$):
The change in the sum of the product probability of all paths between all nodes.

$PC_1 = 6.53$
$PC_2 = 0.88$
$dPC = 5.65$
Using network analysis and connectivity metrics to identify important meadows

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Node removal to measure importance

Change in overall graph connectivity ($dPC$):
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PC$_1$ = 6.53
PC$_2$ = 4.28
dPC = 2.25
Using network analysis and connectivity metrics to identify important meadows

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Node removal to measure importance

Change in overall graph connectivity ($dPC$):
The change in the sum of the product probability of all paths between all nodes
Meadow and link importance to connectivity (dPC)
Defining biologically meaningful regions
Local patch level

Are seagrass meadows connected by passive dispersal?

Are certain meadows more important than others for maintaining connectivity?

Can we use network theory as a tool to identify and protect important groups of meadows?

Regional level
Research Management
Management

Focus sampling efforts
- sample from meadows that represent a range of connectivity importance

Incorporate into planning tools
- 10% of oceans by 2020
- prioritize and give higher weighting in MPA design

Research

Additional trait based scenarios and dynamic community modeling

Field sampling data
- centrality vs. diversity
- connection strength vs. diversity similarity

Genetic testing
Management

Focus sampling efforts
- sample from meadows that represent a range of connectivity importance

Incorporate into reserve planning tools
- 10% of oceans by 2020
- prioritize areas and give higher weighting in MPA design

Research

Additional trait based scenarios and dynamic community modeling

Field sampling data
- centrality vs. diversity
- connection strength vs. diversity similarity

Genetic testing
In summary...

Modeling connectivity can define biologically relevant management units that can maximize the conservation of biodiversity.
Acknowledgements

Patrick Thompson
Coreen Forbes

Susan Allen -
UBC Salish Sea Project

Jason Roberts -
Marine Geospatial Ecology Tools
Using network analysis and connectivity metrics to identify important meadows

Identify “stepping stones”

Betweenness Centrality of a node: the number of shortest paths from all nodes to all other nodes that pass through that node
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