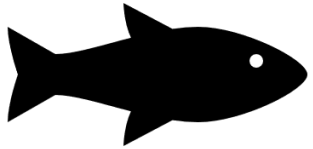
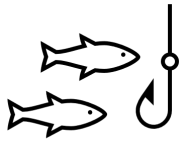
Seventh Meeting of the Scientific Coordination Committee (SCS7)
Sitka, Alaska: August 15-17

Multivariate approaches for EBFM implementation in the U.S. Caribbean

Juan J. Cruz-Motta, Stacey Williams, Tarsila Seara, William Arnold, Graciela Garcia-Moliner, Orian Tzadik, Tauna Rankin, Alida Ortiz, Kevin McCarthy, Maria Lopez-Mercer, Sarah Stephenson, Sennai Habtes, Edwin Cruz-Rivera, Liajay Rivera-Garcia.

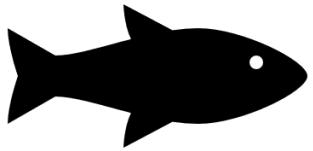
SSFM





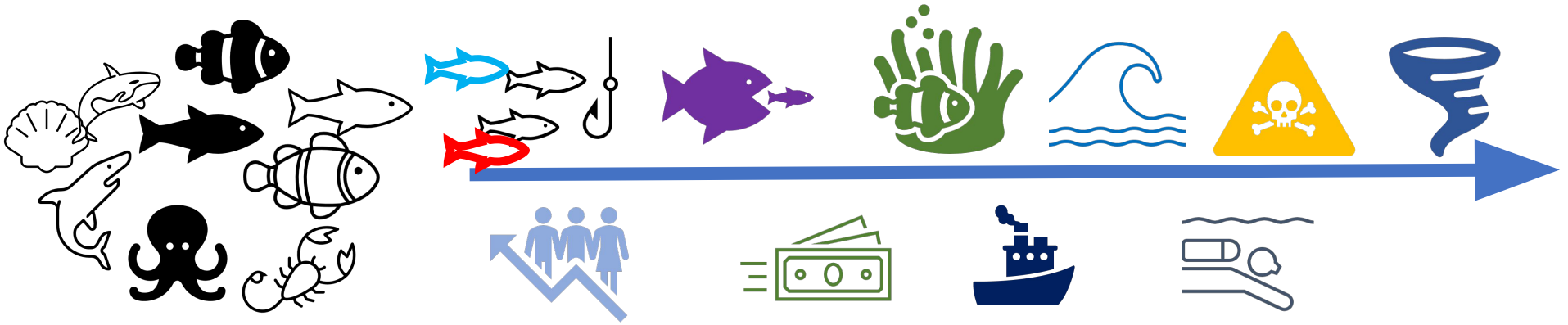
FMP

EAFM



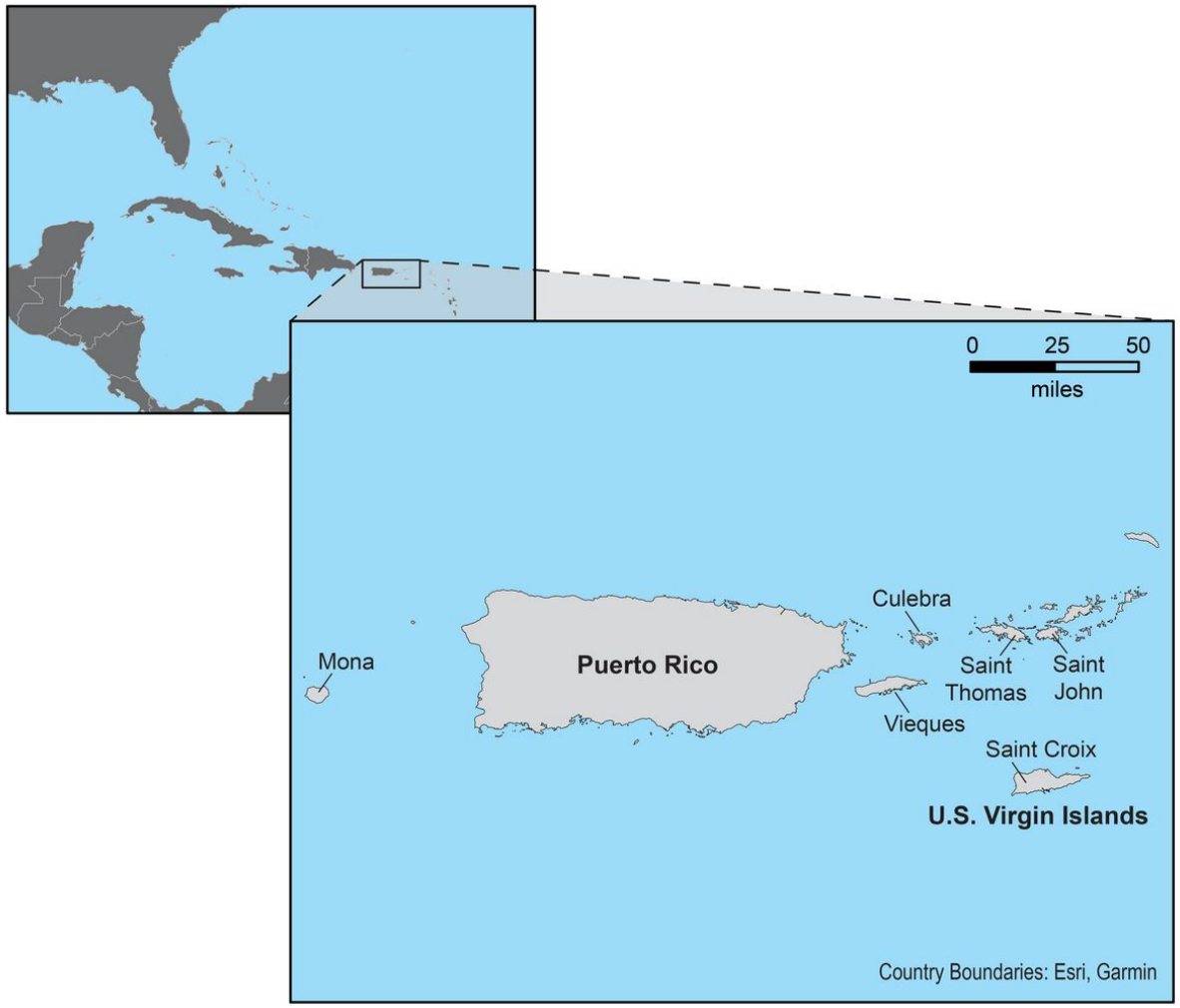
FMP

EBFM



FEP

U.S. Caribbean



- Lowest landings
- Lowest total revenue
- Limited shelf area
- One of deepest EEZ
- No congressional representation
- Lowest Absolute Population
- Data poor
- Fully artisanal fishery

WHY BOTHER???

HOWEVER

- Highest number of managed species
- Highest ecological diversity
- ≈ 80 % Fisheries depends on Coral Reefs
- Relatively high productivity / shelf area
- High Stakeholder involvement

OTHER potential drivers

Multi-specific, Multi-driver, Multi-gear, Multi-objectives SYSTEM

Ideal system to implement EBFM

Perhaps EBFM the only option?

AIM

To develop an **FEP** for the US Caribbean in order to guide the implementation of an **EBFM**

Development of FEPs

Marine Policy 92 (2018) 48–57

Contents lists available at ScienceDirect

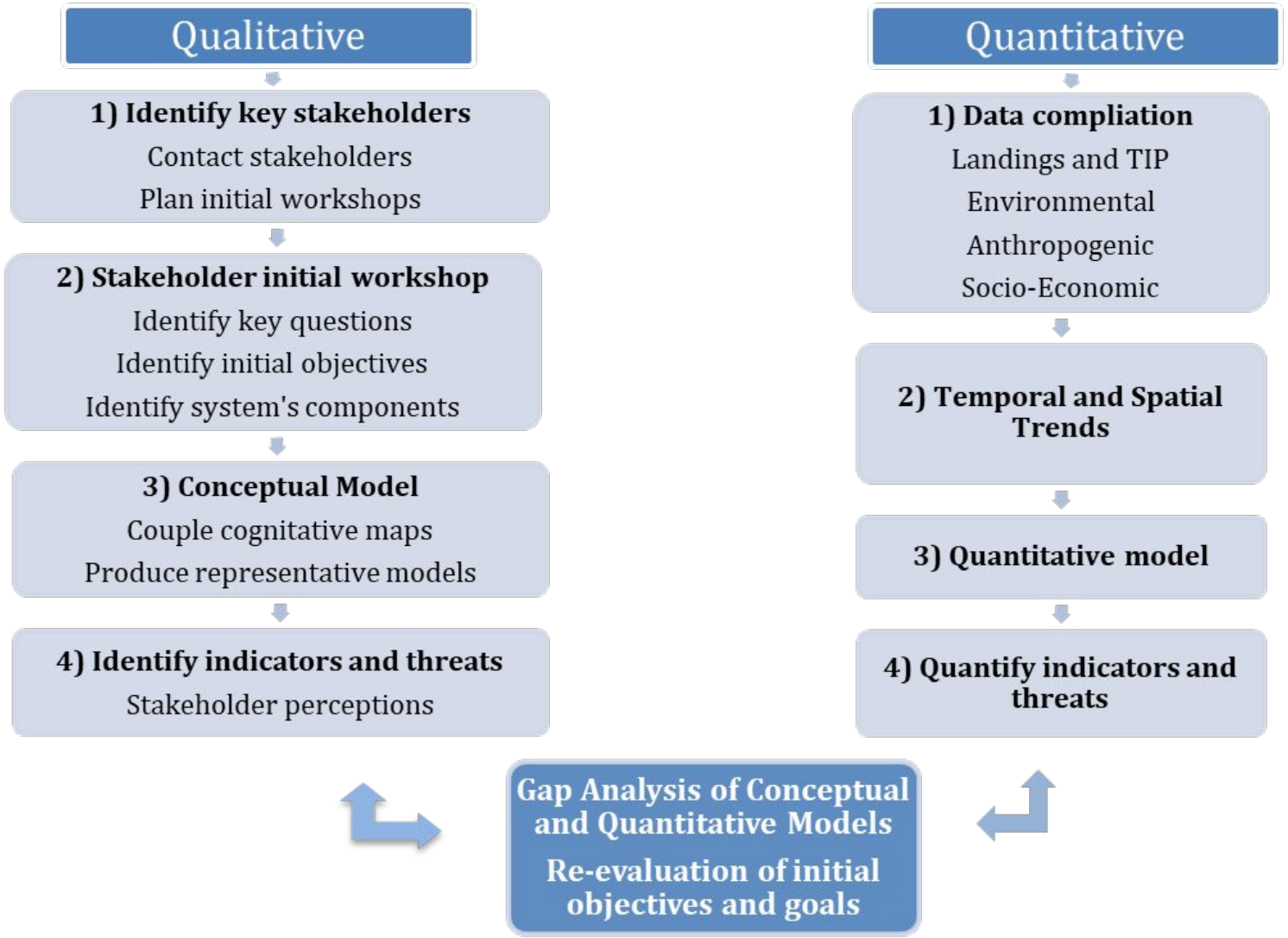
Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Building effective fishery ecosystem plans

Phillip S. Levin[a,*], Timothy E. Essington[b], Kristin N. Marshall[c], Laura E. Koehn[b], Lee G. Anderson[d], Alida Bundy[e], Courtney Carothers[f], Felicia Coleman[g], Leah R. Gerber[h], Jonathan H. Grabowski[i], Edward Houde[j], Olaf P. Jensen[k], Christian Möllmann[l], Kenneth Rose[m], James N. Sanchirico[n], Anthony D.M. Smith[o]

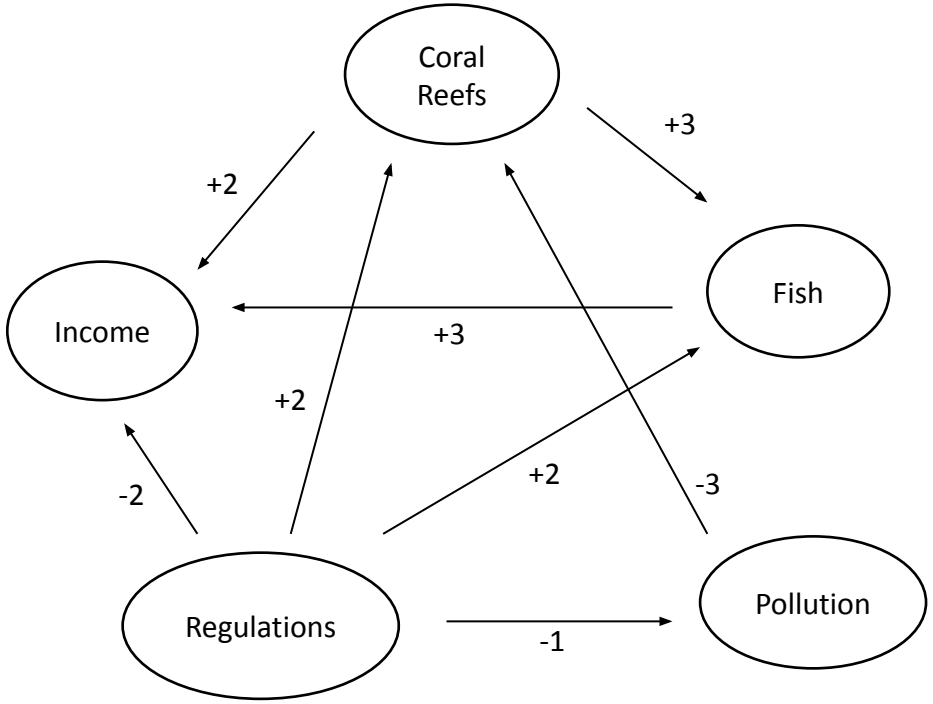
Where are We Now?: Description of the Fisheries System



Qualitative
(Based on stakeholder perception)

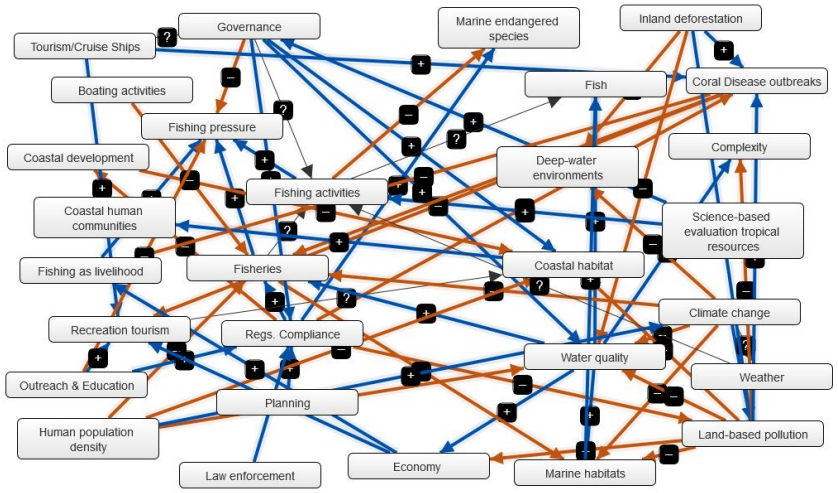
Conceptual Models (Fuzzy Cognitive Maps):

- DAPs = 3 (38)
- SSC = 1 (11)
- PEW (CFCM):
  - Business = 3 (17)
  - NGOs = 3 (20)
- Lenfest Project:
  - Experts = 4 (24)
  - Managers = 3 (9)
  - Fishers = 12 (117)

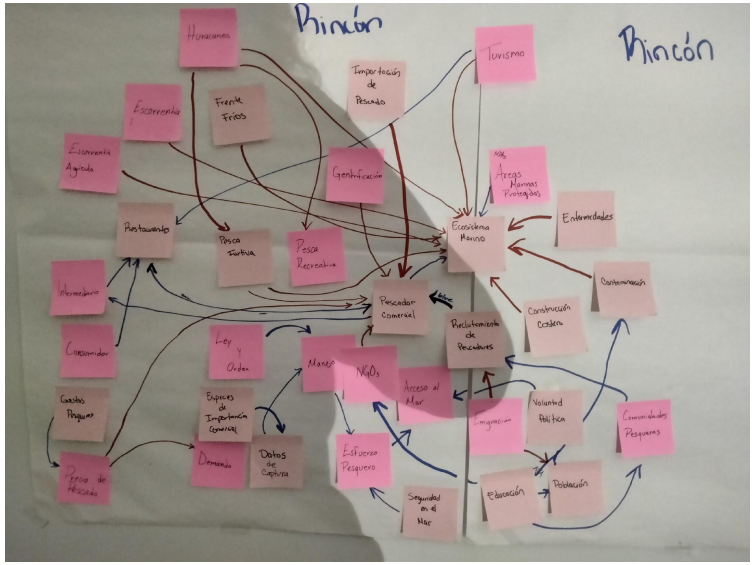


EXAMPLES CONCEPTUAL MODELS

Managers STX/STT/STJ



Fishers PR



29 Models

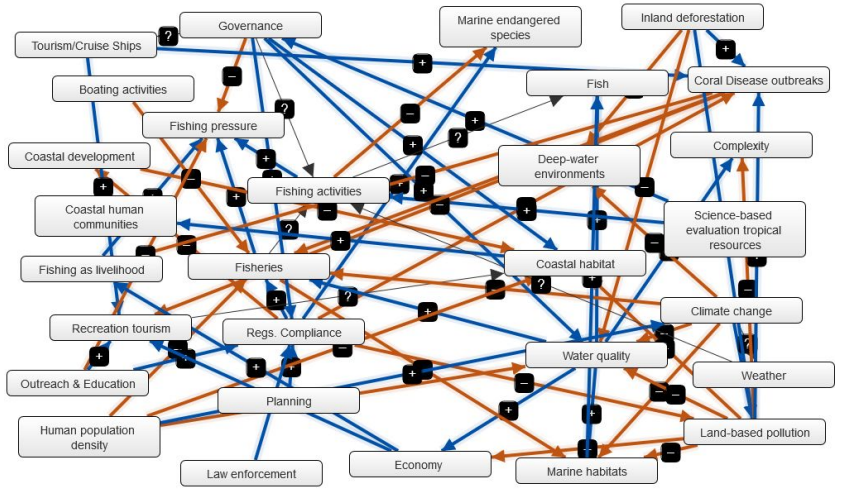
Nested structure

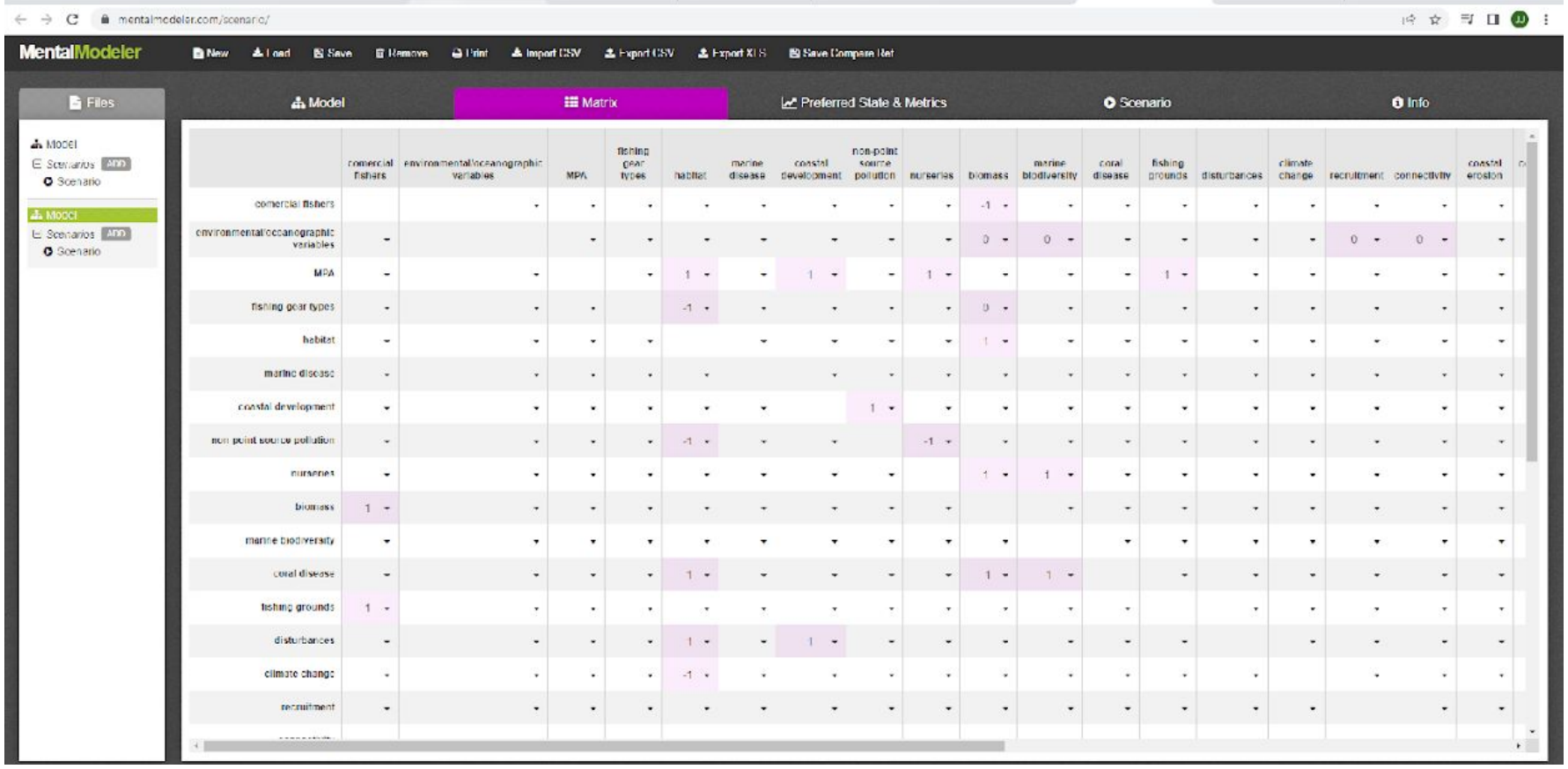
- Different stakeholders
- Different islands/regions per stakeholder group
- Different groups within stakeholders and island

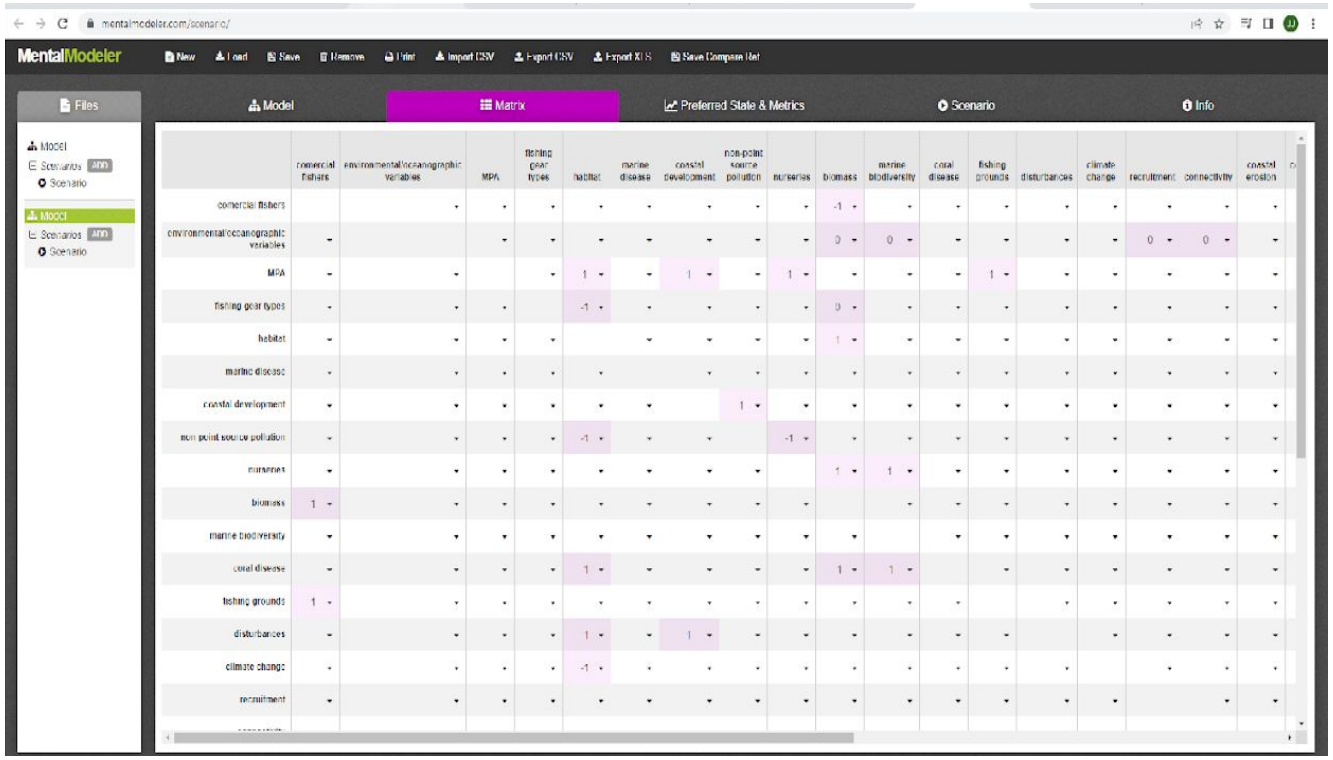
Dra. Alida Ortiz
Chair Outreach and Education Advisory Panel
CFMC

?????????

"Spaghetti Salad"





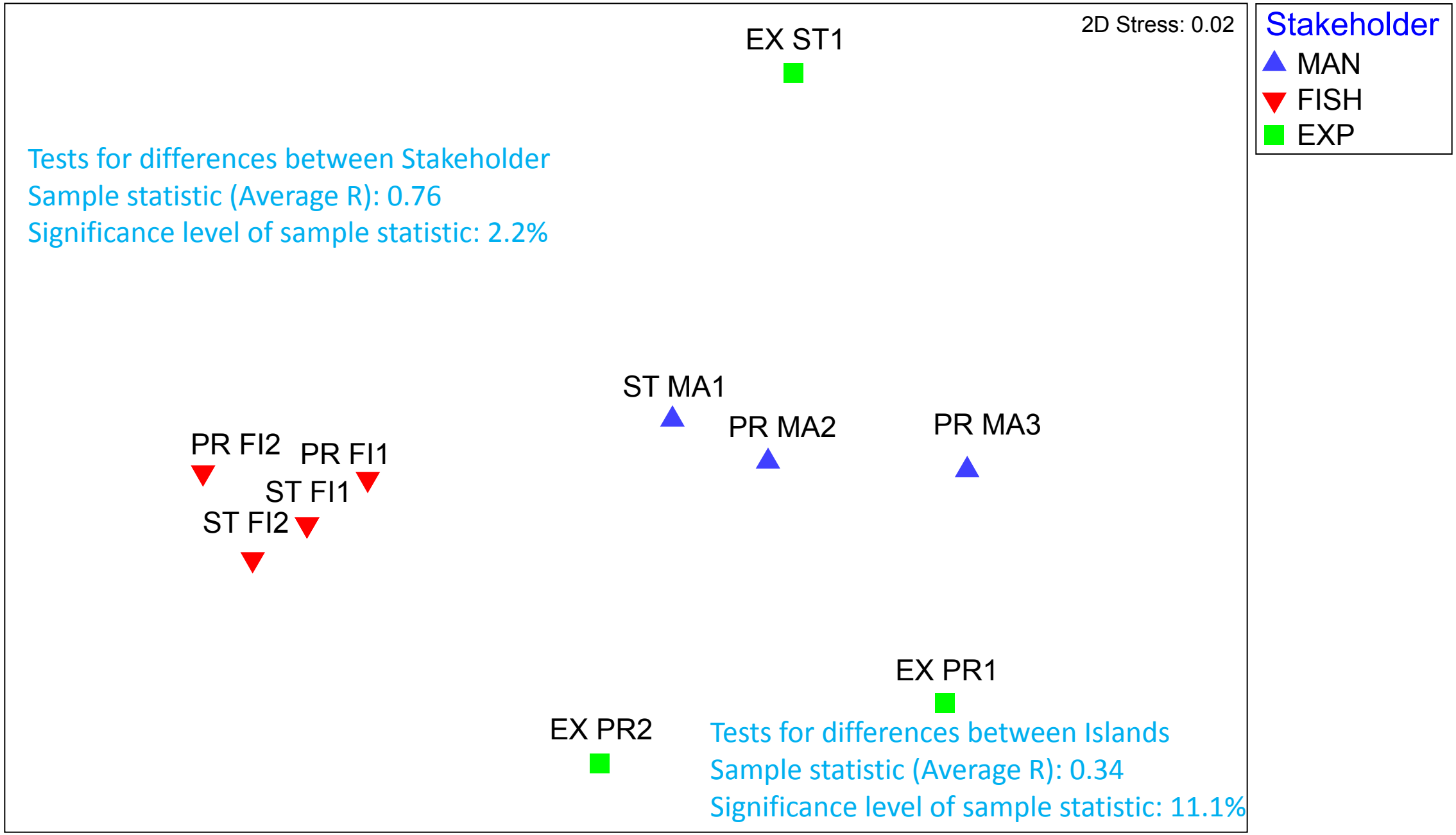


Each vector (relationship) is considered a variable

	ST MA1	PR MA2	PR MA3	ST FI1	ST FI2	PR FI1	PR FI2	EX PR1	EX PR2	EX ST1
Fisheries to Fish assemblages	-1	-1	-1	0	0	0	0	-1	0	1
Fish assemblages to Fisheries	1	1	1	1	1	1	1	0	1	1
Regulations to fisheries	1	1	1	-1	-1	-1	-1	1	1	1
Fisheries to regulations	1	1	1	0	0	0	0	1	0	1
Contamination to fish assemblages	-1	-1	-1	-1	-1	-1	-1	-1	-1	0
Habitat to fish assemblages	1	1	1	1	1	1	1	1	1	0
Tourism to fisheries	1	0	-1	1	1	0	0	-1	-1	-1
Fisheries to tourism	1	1	0	1	1	1	1	0	0	1
Island	STT	PR	PR	STT	STT	PR	PR	PR	PR	STT
Stakeholder	MAN	MAN	MAN	FISH	FISH	FISH	FISH	EXP	EXP	EXP

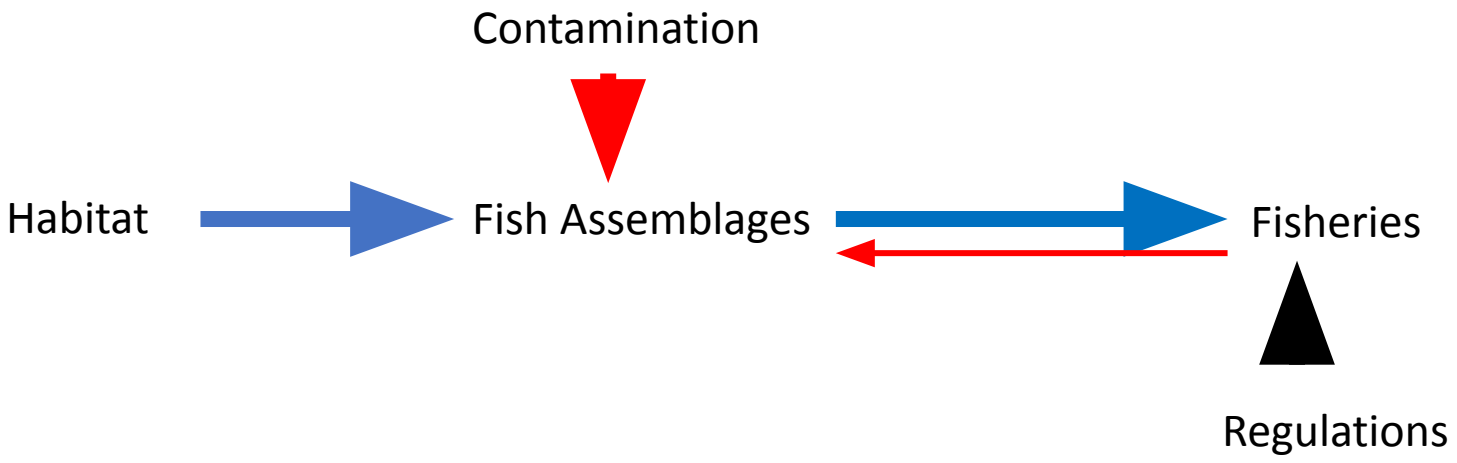
Non-metric MDS

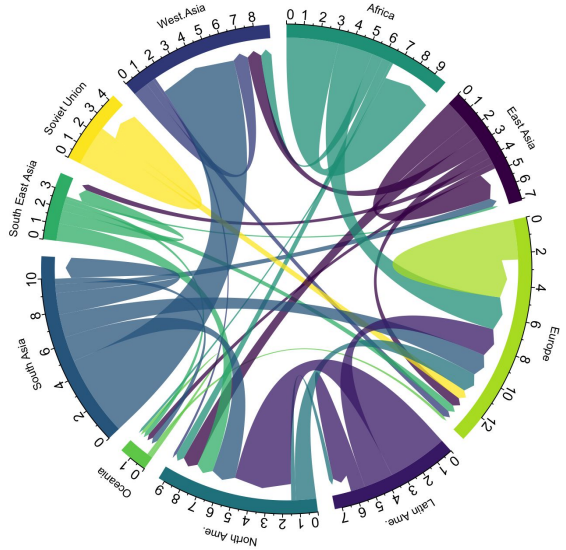
Resemblance: S15 Gower



Example Melded/Simplified Model

	ST MA1	PR MA2	PR MA3	ST FI1	ST FI2	PR FI1	PR FI2	EX PR1	EX PR2	EX ST1		Frequency	Absolute
Fisheries to Fish assemblages	-1	-1	-1	0	0	0	0	-1	0	1		-3	5
Fish assemblages to Fisheries	1	1	1	1	1	1	1	0	1	1		9	9
Regulations to fisheries	1	1	1	-1	-1	-1	-1	1	1	1		2	10
Fisheries to regulations	1	1	1	0	0	0	0	1	0	1		5	5
Contamination to fish assemblages	-1	-1	-1	-1	-1	-1	-1	-1	-1	0		-9	9
Habitat to fish assemblages	1	1	1	1	1	1	1	1	1	0		9	9
Tourism to fisheries	1	0	-1	1	1	0	0	-1	-1	-1		-1	7
Fisheries to tourism	1	1	0	1	1	1	1	0	0	1		7	7
Island	STT	PR	PR	STT	STT	PR	PR	PR	PR	STT			
Stakeholder	MAN	MAN	MAN	FISH	FISH	FISH	FISH	EXP	EXP	EXP			





Highlights:

U.S. Caribbean Conceptual Models

1) Analysis of the entire socio-ecological system. Not only a single the targeted species.

2) Comprehensive stakeholder involvement

3) Stakeholders were interviewed separately. Workshops not “lead” by a specific group or stake holder

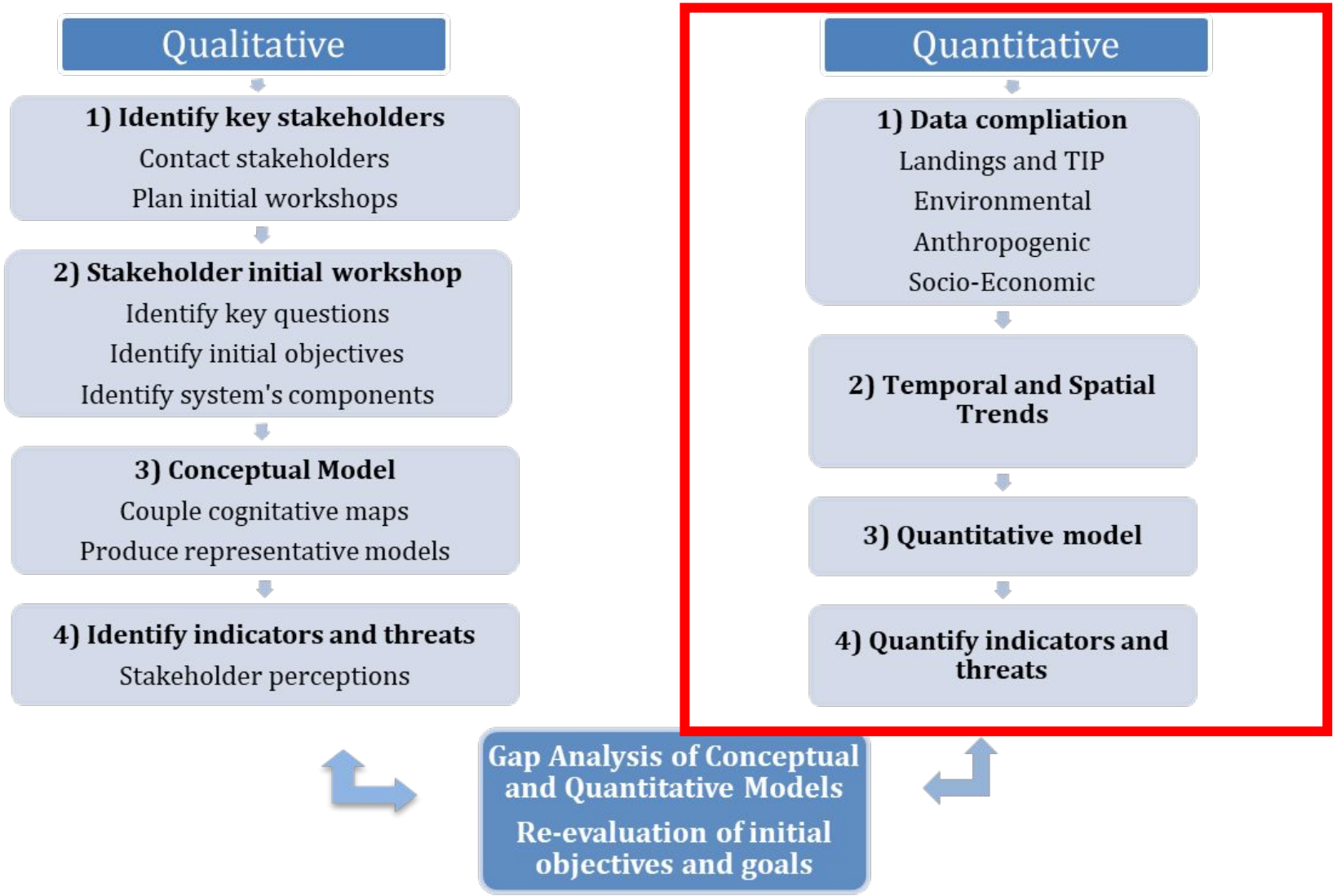
4) Quantitative analyses of conceptual models (perceptions) that will allow to:

    1) Estimate Similarities/Differences within/between stakeholders and islands/regions

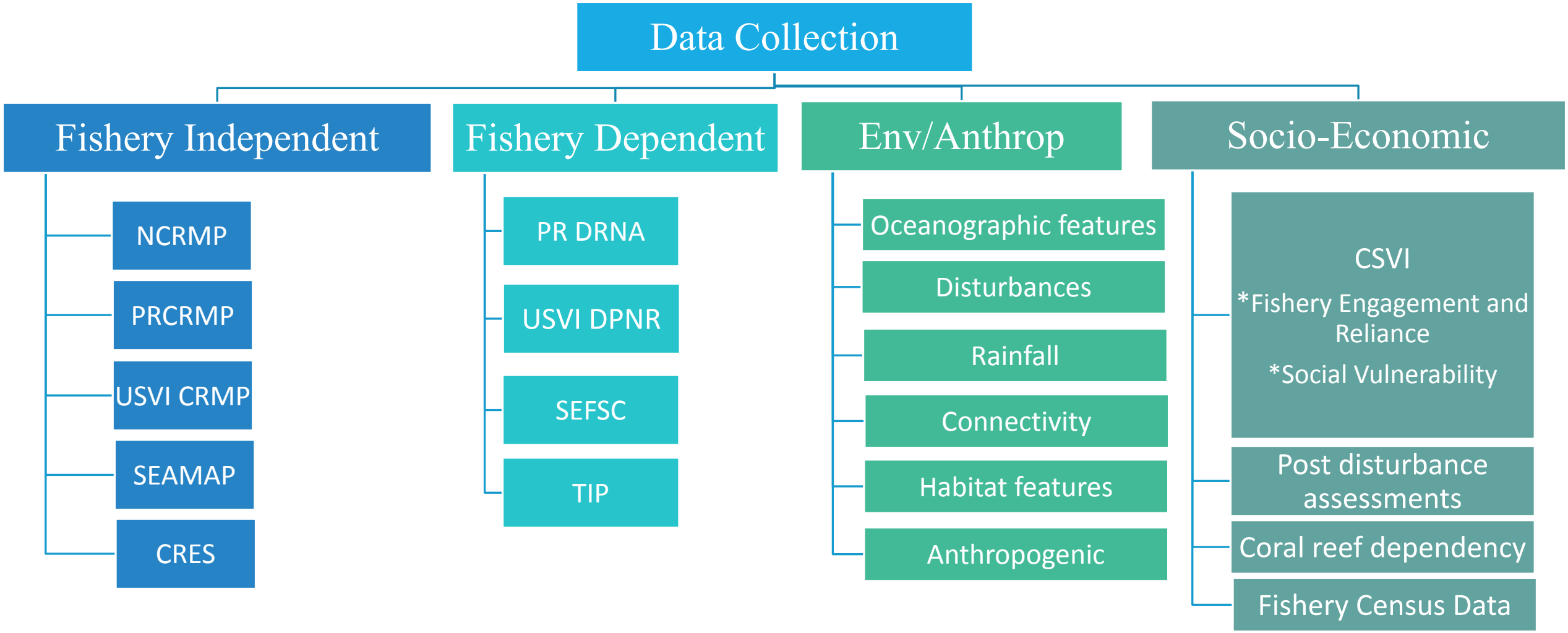
    2) Identify main components and connections to be used on a melded/simplified model

5) Preliminary analyses are showing emerging components not currently considered = Recreational Fisheries

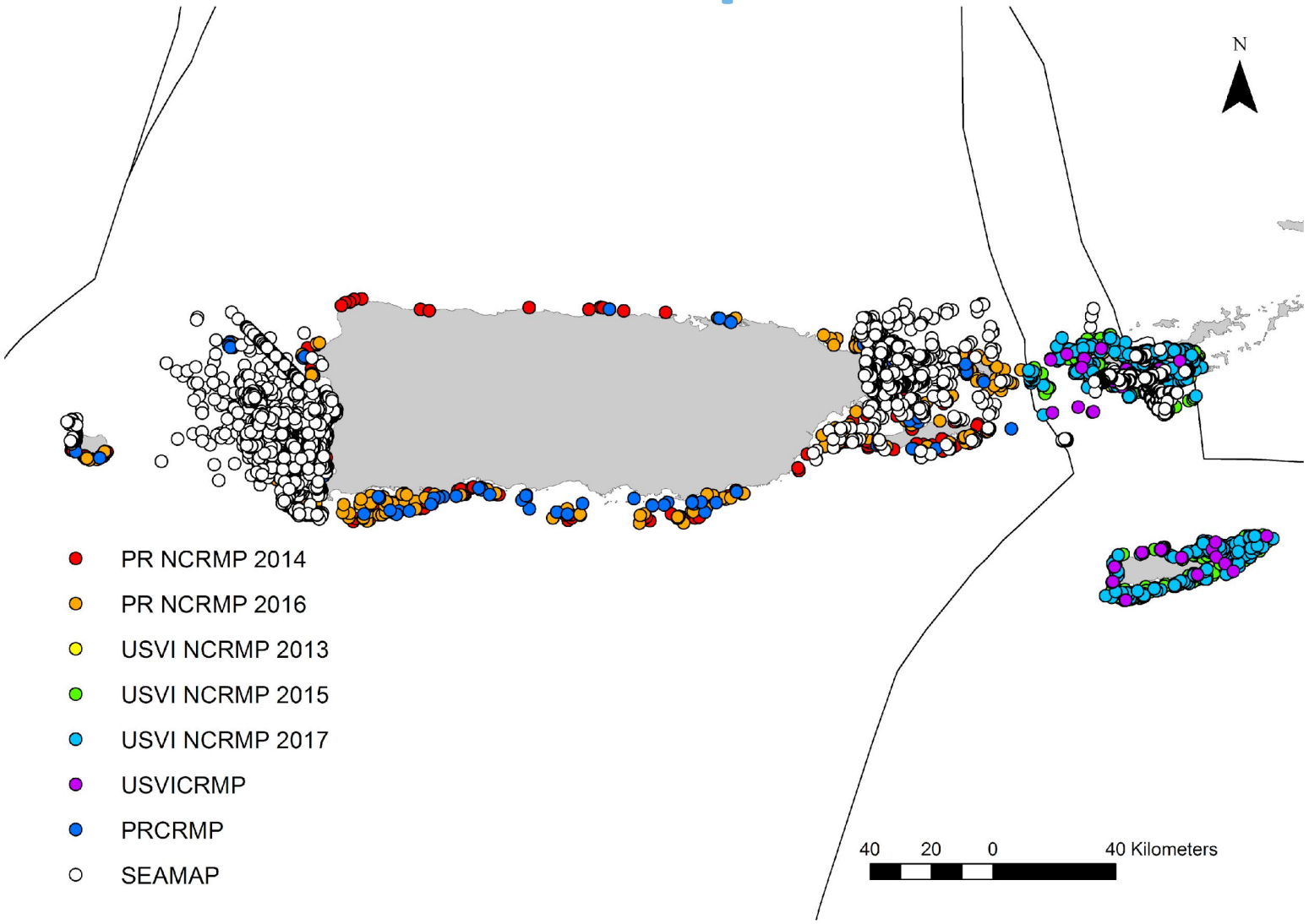
Where are We Now?: Description of the Fisheries System



Quantitative Approach



Fisheries Independent and Habitat Data



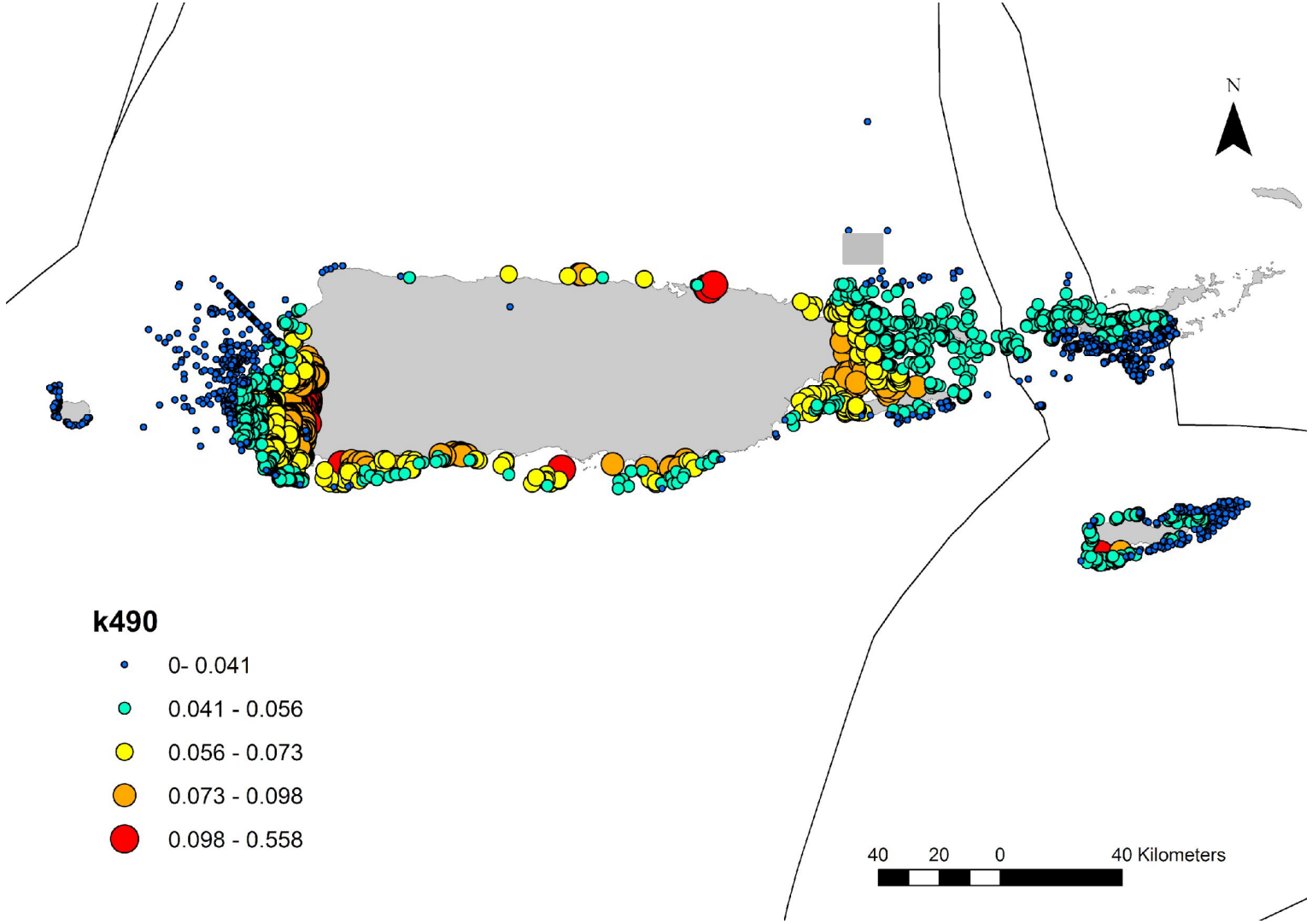
Habitat:

-Type
-Heterogeneity
-Relative cover of coral species
-Relative cover of benthic groups
-Rugosity
-Abundance of invertebrates of interest (e.g. Lobsters, *Diadema*)

Fish Assemblages:

-Abundance per species
-Biomass per species
-Size Class Frequencies per species

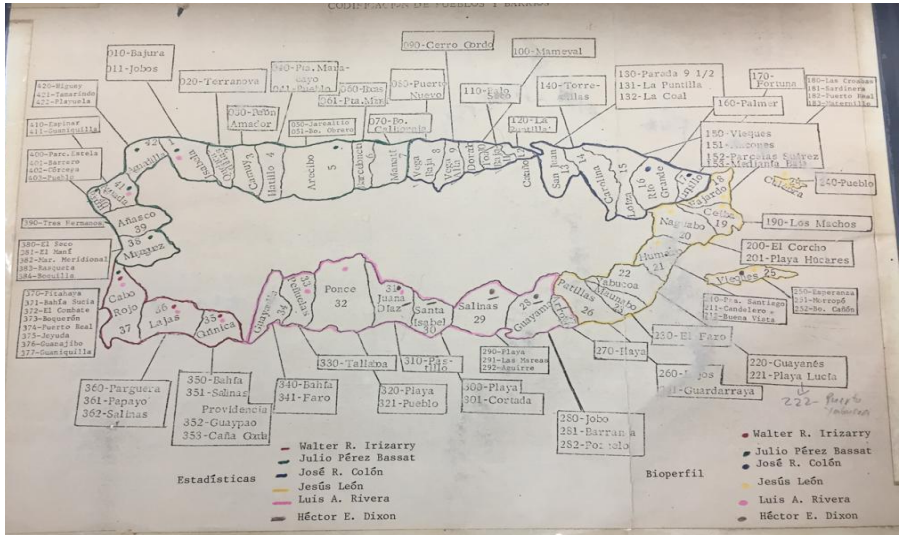
Environmental/Anthropogenic Data



https://oceancolor.gsfc.nasa.gov/l3/order/

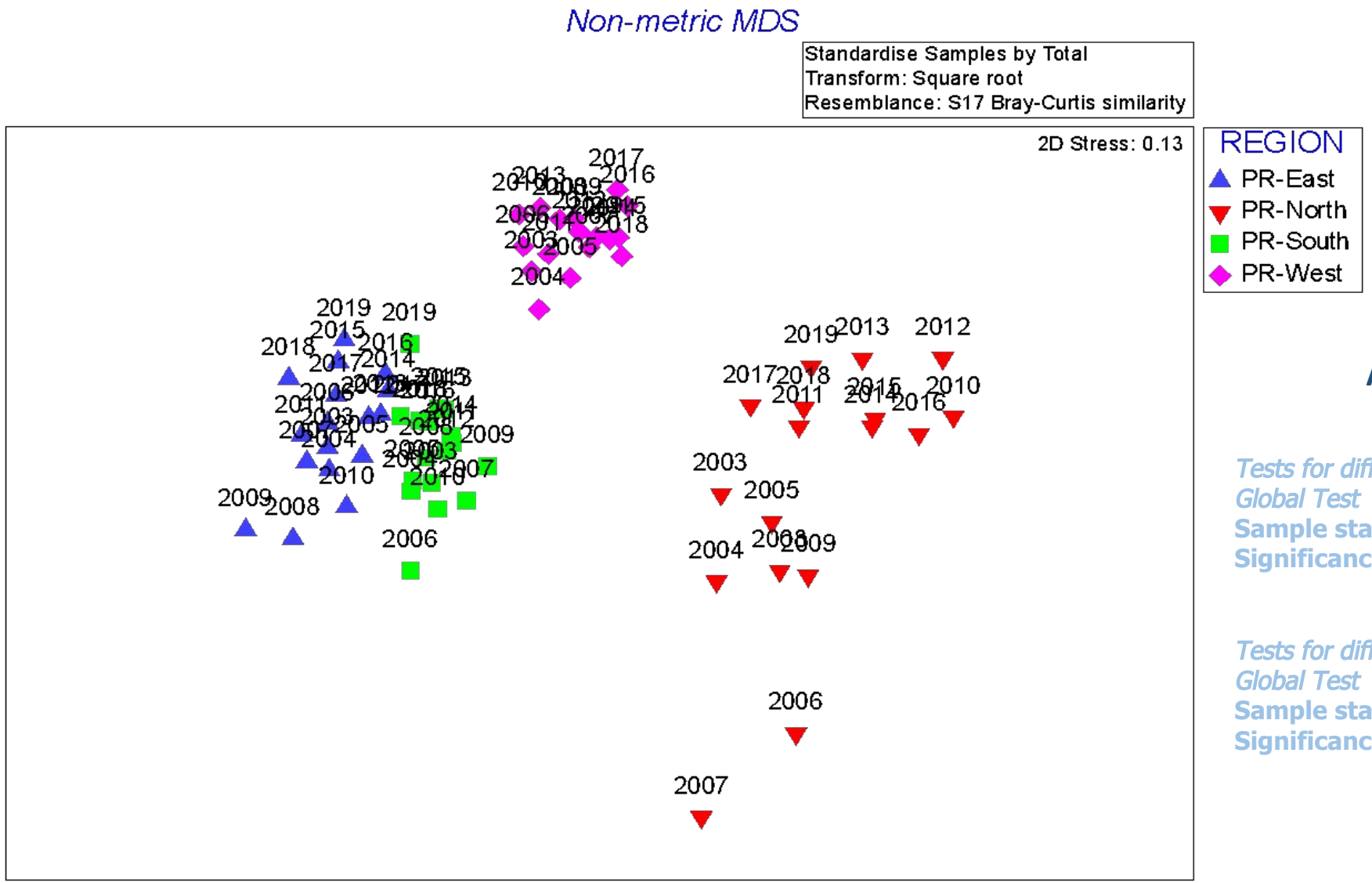
Variable	Data source
Wave exposure	Significant Wave Height
Currents	Current speed
Rainfall	Rainfall
Hurricanes	Hurricane tracks
Distance from port	Port location
Depth	Bathymetry
Proximity to closest MPA	MPA location
Proximity to spawning aggregation	Location of fish spawning aggregation sites
Reef area	Habitat map
Habitat type	Habitat map
Habitat heterogeneity	Habitat map
Nursery habitat	Habitat map
Connectivity	Larval connectivity data
Human population density	Human population data
Human population density	Gravity of human impacts
Distance from shelf break	Continental margin
Sea surface temperature	Same as 21
anomalies (DHW)	Sea Surface Temperature
Slope	Bathymetry
Turbidity	Diffuse attenuation K490
discharge	Hydrography
Productivity	Net primary production
Water Pollution	Reef at Risk
Inorganic Pollution	Halpern Model
Proximity to MPA	MPA location

Landings data (SEFSC): Response variable (Biomass) 1983 -2020



	BARRACUDA	JACKS	MACKEREL, KING	PORGY, UNSPECIFIED	TUNA AND MACKERELS, UNSPECIFI	GROUPER, UNSPECIFIED	SNAPPER, LANE	SNAPPER, MUTTON	SNAPPER, SILK	SNAPPER, YELLOWTAIL	LOBSTERS, SPINY	SNAPPER, UNSPECIFIED		YEAR	REGION	LOCATION	GEAR
S1	0	0	0	0	0	0	0	0	0	0	2359.01639	0		1983	PR-East	CEIBA	BY HAND, DIVING GEAR
S2	0	0	0	0	0	0	0	0	0	0	0	0		1983	PR-East	CEIBA	HAUL SEINES
S3	0	0	0	906.557377	0	1732.786885	627.868852	88.5245902	0	1345.90164	0	0		1983	PR-East	CEIBA	HOOK AND LINE, BOTTOM
S4	0	0	0	1909.836066	0	3455.737705	9993.44262	724.590164	0	1422.95082	301.639344	0		1983	PR-East	CEIBA	POTS AND TRAPS, FISH
S5	0	0	108.196721	0	0	0	0	0	0	0	0	0		1983	PR-East	CEIBA	TROLL LINES
S6	0	0	0	0	0	0	0	0	0	0	2498.36066	0		1983	PR-East	CULEBRA	BY HAND, DIVING GEAR
S7	0	0	195.081967	0	0	3906.557377	0	0	0	2419.67213	0	0		1983	PR-East	CULEBRA	HOOK AND LINE, BOTTOM
S8	0	0	0	0	0	1632.786885	122.95082	106.557377	0	1062.29508	0	0		1983	PR-East	CULEBRA	POTS AND TRAPS, FISH
S9	0	0	0	0	0	0	0	0	0	0	1677.04918	0		1983	PR-East	CULEBRA	POTS AND TRAPS, SPINY LOBSTER
S10	0	0	1139.34426	0	0	60.65573771	0	0	0	0	0	0		1983	PR-East	CULEBRA	TROLL LINES
S11	0	0	0	0	0	0	0	0	0	0	7829.5082	0		1983	PR-East	FAJARDO	BY HAND, DIVING GEAR
S12	0	0	0	0	0	73.7704918	118.032787	0	0	36.0655738	0	0		1983	PR-East	FAJARDO	GILL NETS, OTHER
S13	1290.163934	0	278.688525	0	0	0	0	19.6721311	0	647.540984	0	0		1983	PR-East	FAJARDO	HAUL SEINES
S14	0	0	2800	19.67213115	0	2318.032787	1308.19672	929.508197	788.52459	28239.3443	0	0		1983	PR-East	FAJARDO	HOOK AND LINE, BOTTOM
S15	0	0	0	0	0	62.29508197	103.278689	65.5737705	0	50.8196721	0	0		1983	PR-East	FAJARDO	LONG LINES, BOTTOM
S16	42.62295082	0	155.737705	1496.721311	0	9913.114754	2221.31148	1583.60656	0	2675.40984	859.016393	32.78688525		1983	PR-East	FAJARDO	POTS AND TRAPS, FISH
S17	0	0	25301.6393	0	0	204.9180328	0	0	0	0	0	0		1983	PR-East	FAJARDO	TROLL LINES
S18	0	0	0	0	0	18.03278689	0	0	0	0	2467.21311	0		1983	PR-East	HUMACAO	BY HAND, DIVING GEAR
S19	0	0	0	0	0	0	0	0	0	0	0	0		1983	PR-East	HUMACAO	CAST NETS
S20	0	0	0	0	0	0	386.885246	0	0	0	0	0		1983	PR-East	HUMACAO	GILL NETS, OTHER
S21	0	0	0	0	0	0	0	0	0	0	0	0		1983	PR-East	HUMACAO	HAUL SEINES
Indicators	Barracuda	Jacks	Scomb	Porgy	Scomb	Grouper	Snapper	Snapper	Snapper	Snapper	Lobster	Snapper					

Description of Temporal Trends and Spatial patterns Landings 2003-2019

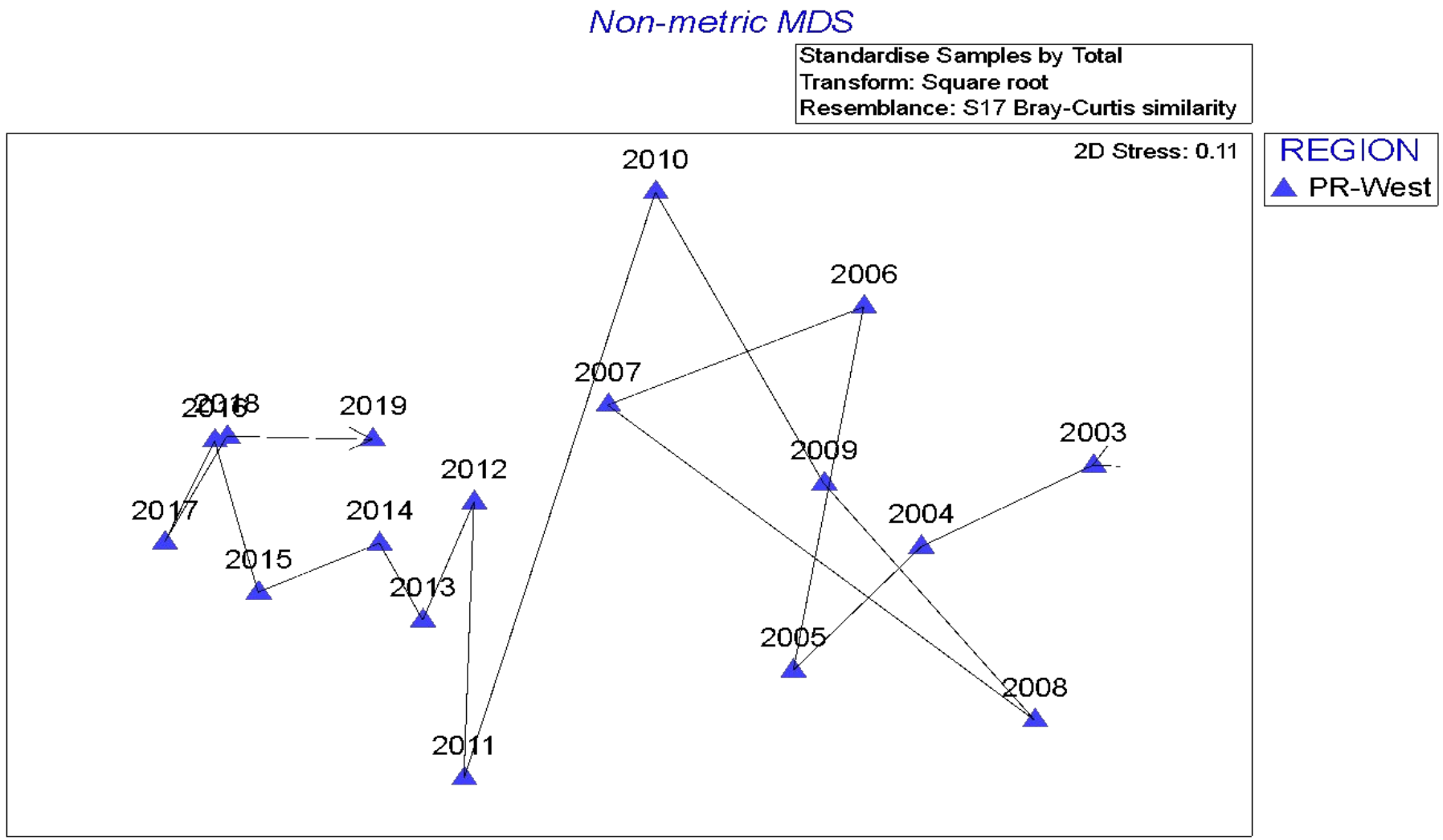


Analysis of similarities

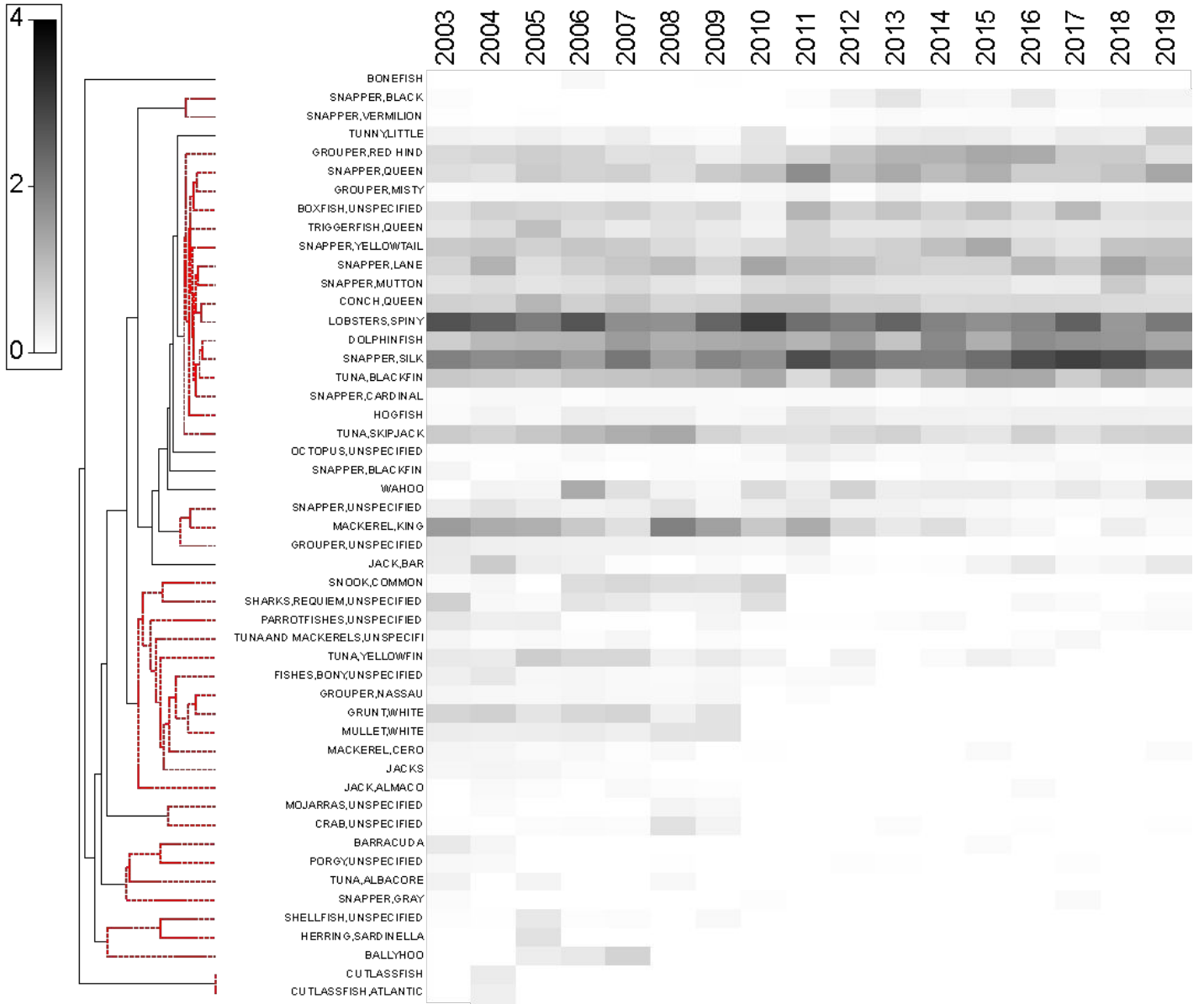
Tests for differences between unordered ***REGION***
Global Test
Sample statistic (Average R): 0.742
Significance level of sample statistic: 0.1%

Tests for differences between ordered ***YEAR***
Global Test
Sample statistic (Average R): 0.646
Significance level of sample statistic: 0.1%

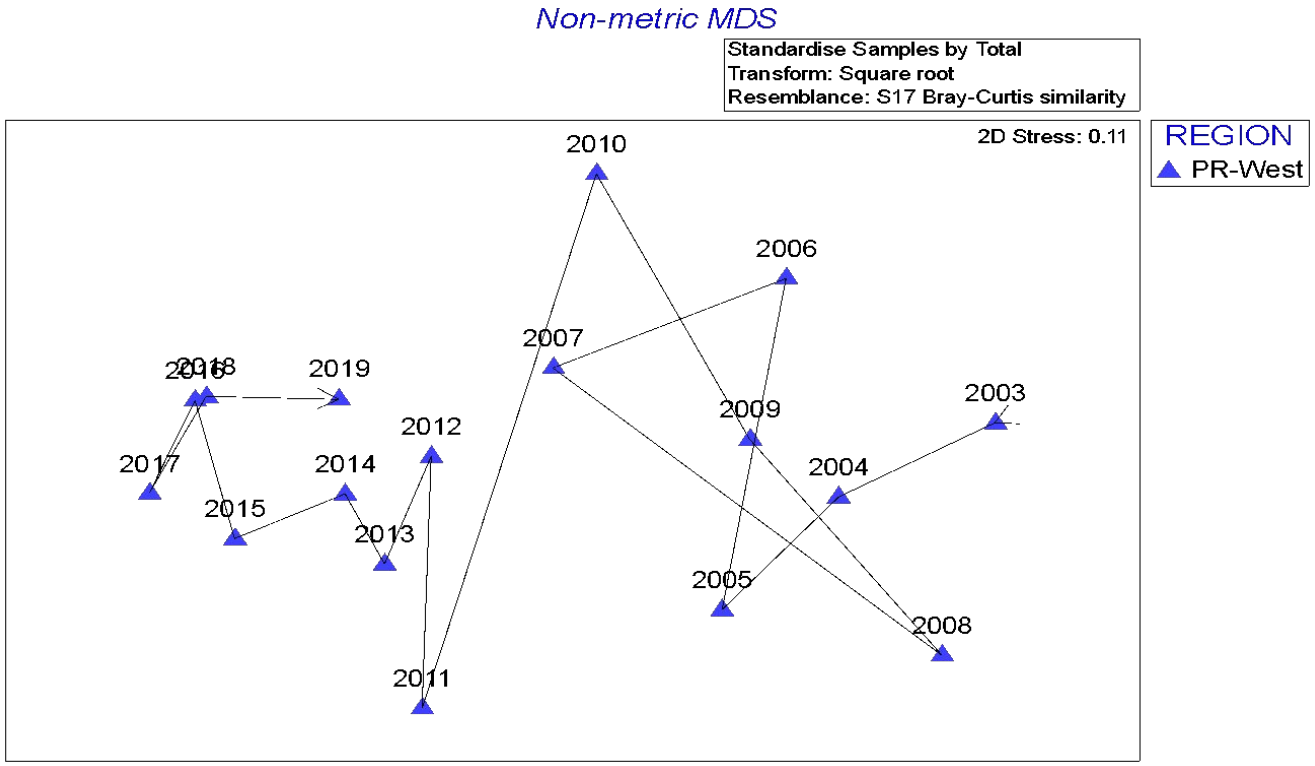
Landings temporal trends 2003-2019
West coast PR (EXAMPLE)



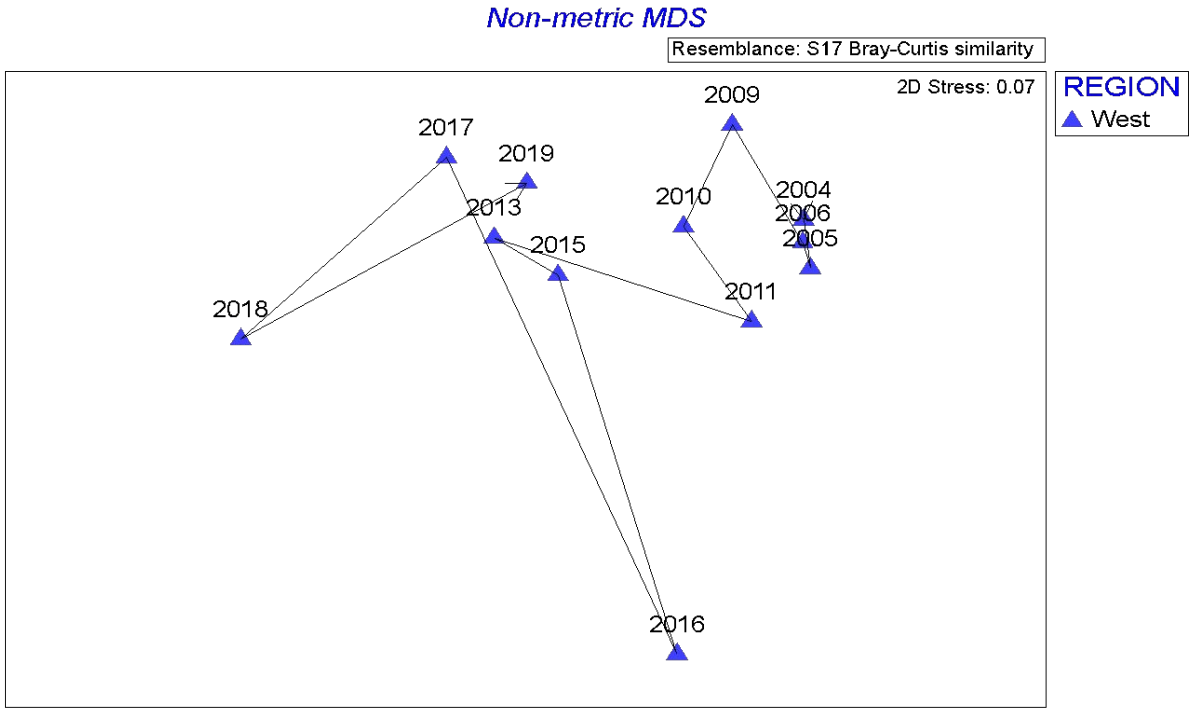
Landings temporal trends 2003-2019
West coast PR (EXAMPLE)



Landings

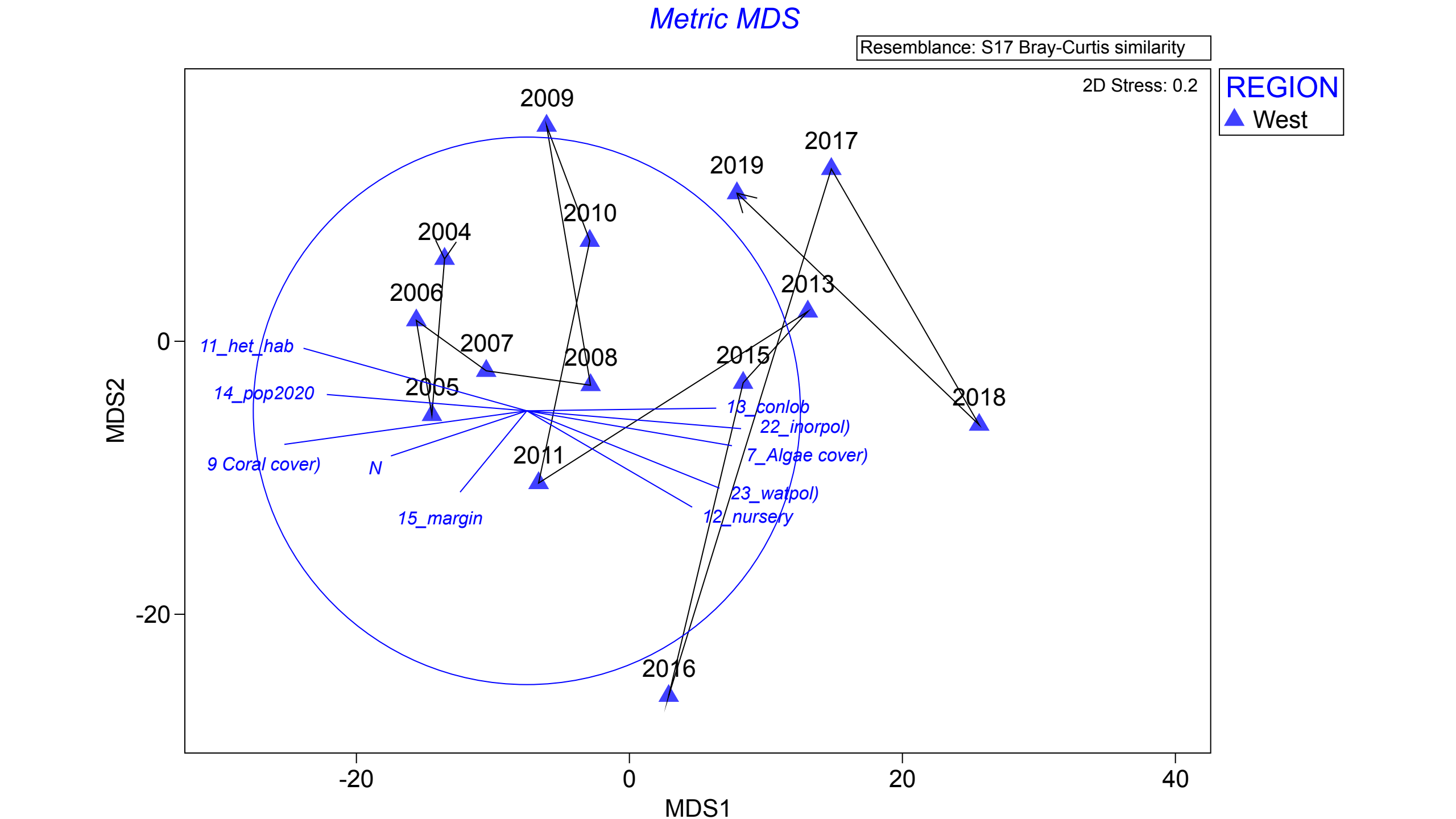


Fisheries Independent



RELATE (Rho)

Sample statistic (Rho): 0.473
Significance level of sample statistic: 0.009
Number of permutations: 9999


Metric MDS
Resemblance: S17 Bray-Curtis similarity
2D Stress: 0.2
REGION
West
2009
2017
2019
2010
2004
2013
2006
2007
2008
2015
2018
2005
2011
2016
11_het_hab
14_pop2020
9 Coral cover)
N
15_margin
13_conlob
22_inorpol)
7_Algae cover)
23_watpol)
12_nursery
MDS2
MDS1
0
-20
-20
0
20
40

FINAL MESSAGE:

(For the Caribbean case)

- Description of temporal trend using a **multispecific** approach:
  Fisheries, Fish Assemblages and Drivers

- Identify alternative (potential) **drivers**:
  Indicators and Threats

However

- Need to Manage Fisheries outside CFCM jurisdiction:
  emerging and novel cross-mandate policymaking process?

Thanks to:

- **Lenfest Ocean Program: Funding**
- **CFCM: Funding**
- **All stakeholders that participated in the workshops**


Questions???