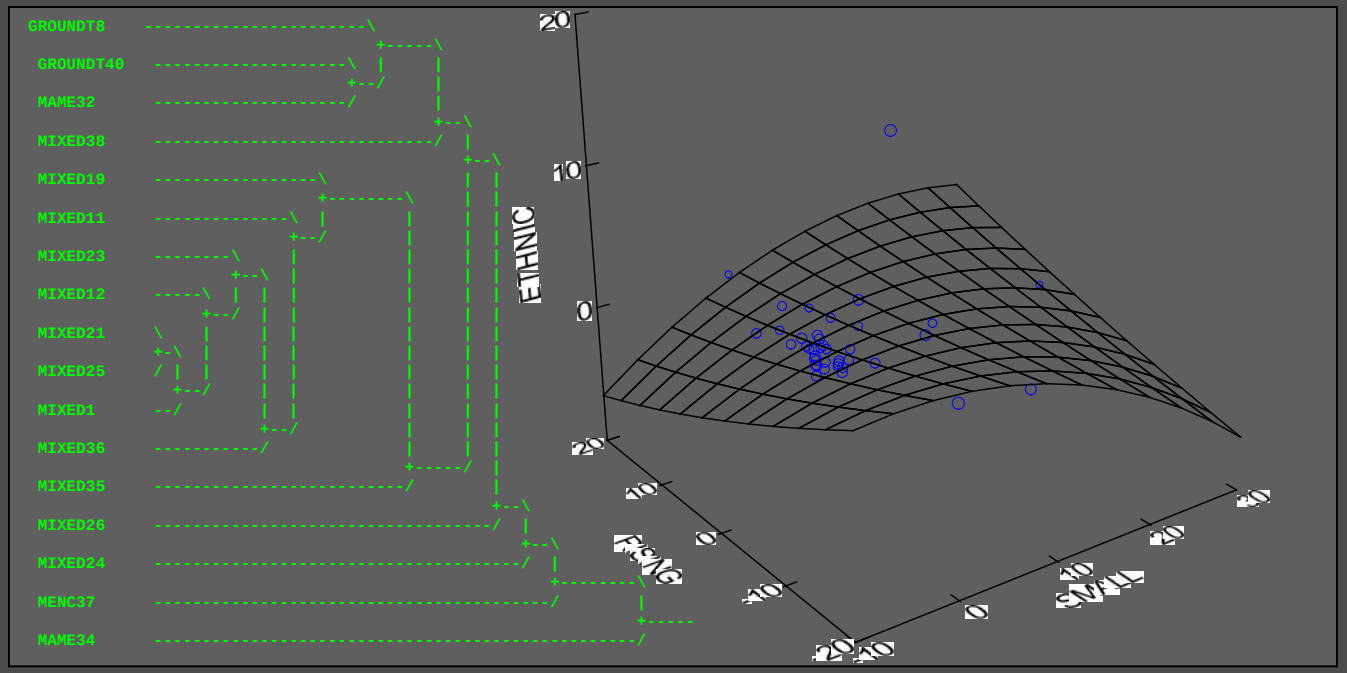
TYPING OF FISHING COMMUNITIES USING MULTIVARIATE ANALYSIS



THE PROBLEM

- FROM NORTH CAROLINA NORTH TO THE CANADIAN BORDER THERE ARE ALMOST 2000 COMMUNITIES SOMEHOW INVOLVED IN THE COMMERCIAL FISHERY.
- MANAGEMENT DECISIONS REQUIRE SOCIAL IMPACT ANALYSIS—IDEALLY AVAILABLE PRIOR TO DECISION TIME.
- THERE ARE NOT SUFFICIENT RESOURCES TO ACQUIRE “NECESSARY” INFORMATION ON ALL COMMUNITIES.

A POTENTIAL SOLUTION

- IF WE COULD CLASSIFY OR TYPE THESE ALMOST 2000 COMMUNITIES INTO SMALLER GROUPINGS, SOCIAL IMPACT ANALYSIS DATA FROM SEVERAL WITHIN EACH GROUP WOULD PROVIDE BETTER PREPARATION FOR DECISION MAKING.
- THE PROBLEM, THEREFORE IS ONE OF CLASSIFICATION OR CREATING A TAXONOMY OF FISHING COMMUNITIES.

THE METHODS

- FOR THE MOST PART, MODERN BIOLOGY USES SYSTEMATICS TO CLASSIFY ORGANISMS—TOOLS SUCH AS MULTIPLE DISCRIMINANT ANALYSIS AND CLUSTER ANALYSIS.
- IT IS IMPORTANT TO NOTE THAT UNLESS ONE MEASURES EVERY ASPECT OF THE ITEMS TO BE CLASSIFIED, INFORMED, HUMAN DECISION MAKING IS SIGNIFICANTLY INVOLVED IN THE PROCESS.

THE DATABASE
ALL STAGES REQUIRE DECISIONS

- NEFSC “SOCIAL SCIENCE DATA BASE” WITH FISHERIES AND US CENSUS DATA FOR 1835 “PORTS” FROM NORTH CAROLINA TO THE CANADIAN BORDER.
- FROM THIS WE SELECTED 43 “FISHERY” AND 25 “SOCIAL” VARIABLES FOR ANALYSIS.
- A TOTAL OF 68 VARIABLES……..

DATA REDUCTION
ALL STAGES REQUIRE DECISIONS

- PRINCIPAL COMPONENT ANALYSIS WAS USED TO REDUCE THE LARGE NUMBER OF FISHERY AND SOCIAL VARIABLES TO A SMALLER NUMBER FOR CLASSIFICATION PURPOSES (Scree test for number of components & varimax (orthogonal) rotation)
- RESULTS: 4 FISHERY COMPONENTS AND 3 SOCIAL COMPONENTS.

VARIABLE	COMPONENT 1	2	3	4
Value of scallop 2003	**.932**	.024	.068	.201
Landings value for home-ported vessels 2004	**.930**	.196	.215	.110
Number of large vessels (>70ft) 2004	**.932**	.184	.219	.084
Average value of home-ported vessels 1997-2003	**.907**	.243	.265	.059
Value of landings at dealer reported port 2004	**.867**	.282	.187	.140
Number of large vessels by owner city 2003	**.881**	.220	.122	.182
Total gross tonnage for home-ported vessels	**.852**	.345	.326	.154
Value of large-mesh groundfish 2003	**.832**	.407	.007	.023
Value of skates 2003	**.821**	.175	.220	.071
Average landed value 1997-2003	**.816**	.290	.248	.071
Total gross tonnage for city owner vessels 2004	**.789**	.376	.185	.302
Value of redcrab 2003	**.730**	.014	-.042	.132
Value of monkfish 2003	**.668**	.435	.216	-.058
Number of small vessels (<50ft) by owner city 2003	-.027	**.901**	.054	.307
Number of small vessels by homeport 2003	.041	**.904**	.272	.162
Average number of vessels by owner city 1997-2003	.322	**.843**	.128	.282
Number of vessels by owner city 2004	.350	**.825**	.105	.346
Average number of home-ported vessels 1997-2003	.393	**.798**	.381	.097
Number of home-ported vessels 2004	.416	**.793**	.344	.169
Number of active owner city vessels 2004	.507	**.691**	.193	.308
Number of federal dealers 2004	.487	**.657**	.071	.020
Number of active home-ported vessels 2004	.535	**.646**	.451	.145
Average number of dealers 1997-2003	.484	**.688**	.084	-.020
Value of lobster 2003	.087	**.575**	.012	.091
Value of herring 2003	.516	**.555**	-.023	-.106
Number of medium vessels (50-70ft) by owner city 2003	.502	**.525**	.281	.282
species diversity (number of species landed) 2003	.147	**.502**	.452	-.026
Value of summer flounder, scup, black sea bass 2003	.243	.087	**.780**	.002
Value of butterfish, mackerel, squid 2003	.193	.103	**.710**	-.080
Value of smallmesh multispecies 2003	.440	.119	**.683**	.201
Value of tilefish 2003	-.093	.070	**.648**	.431
Number of medium (50-70ft) vessels by home-port 2003	.518	.489	**.557**	-.003
Value of bluefish 2003	-.007	.107	**.488**	.147
Difference in HP gross tons from 1997/1998 to 2003/2004	-.230	.021	-.199	**-.776**
Difference in city owner gross tons from 97/98 to 2003/2004	-.306	-.094	-.339	**-.656**
Difference in HP vessels from 1997/1998 to 2003/2004	-.130	-.304	.097	**-.641**
Diff. in number of city owner vessels from 97/98 to 03/04	-.200	-.274	.019	**-.622**
Value of dogfish 2003	-.059	.398	.055	.028
Value of surf clam, ocean quahog 2003	.357	.013	.116	-.006
Difference in dealers from 1997/1998 t0 2003/2004	.144	.363	.024	-.156
Value of other species 2003	.091	.065	.166	-.025
Difference in landings values for 1997/1998 to 2003/2004	**-.857**	-.247	-052	-.227
Diff. in sum landings for HP vessels from 97/98 to 03/04	**-.928**	-.101	-.085	-.242

Principal Component Analysis, varimax rotation. Total variance = 70.4%

Fishery data: 4 Factors

Factor 1. large landings, vessels, scallops, large groundfish, skates, red crab & monkfish. Decreasing landings

Factor 2. small vessels, many vessels, lobster, herring and many species

Factor 3. medium sized vessels, bluefish, tilefish, butterfish, mackerel, squid, summer flounder, scup, black sea bass

Factor 4. increasing vessels, vessel GT

COMPONENT SCORES CALCULATED FOR EACH OF THE 4 FISHERY COMPONENTS

Factor Analysis of Social Data

	COMPONENT		
	1	2	3
Median household income	**-0.793**	0.395	0.018
High school (%)	**-0.766**	0.172	-0.413
High school males (%)	**-0.745**	0.243	-0.359
Poverty rate	**0.735**	-0.209	0.309
High school female (%)	**-0.732**	0.088	-0.444
Unemployed (%)	**0.727**	0.279	0.038
Unemployed males (%)	**0.659**	0.277	0.029
Unemployed females (%)	**0.657**	0.229	0.044
Household income >200K (%)	**-0.624**	0.302	0.104
Share of HH income >200k	**-0.579**	0.296	0.118
Share of HH income retired	**0.526**	-0.291	-0.247
Black (%)	**0.520**	0.121	0.447
Males in fishing related job (%)	0.080	**-0.846**	0.002
Fishing related employment (%)	0.054	**-0.845**	0.018
Population in urban area (%)	-0.156	**0.599**	0.271
Females in fishing rel. job (%)	0.035	**-0.549**	0.001
Tourist housing (%)	0.016	**-0.475**	-0.256
Hispanic (%)	0.216	0.174	**0.766**
Other ethnic group (%)	0.276	0.135	**0.745**
White (%)	-0.455	-0.200	**-0.690**
Two or more ethnicities	0.187	0.155	**0.612**
Population	-0.078	-0.095	**0.570**
Aggregate household income	-0.111	-0.091	**0.566**
Asian (%)	-0.230	0.280	**0.451**
Male population (%)	-0.179	-0.186	0.083
Percent of Total Variance	24.072	13.358	15.469

Social Data: 3 Factors

•Factor 1: Poverty/Unemployment (Unemployment - Household income (-) - Education level - Percentage black - Poverty level - Retirement income)

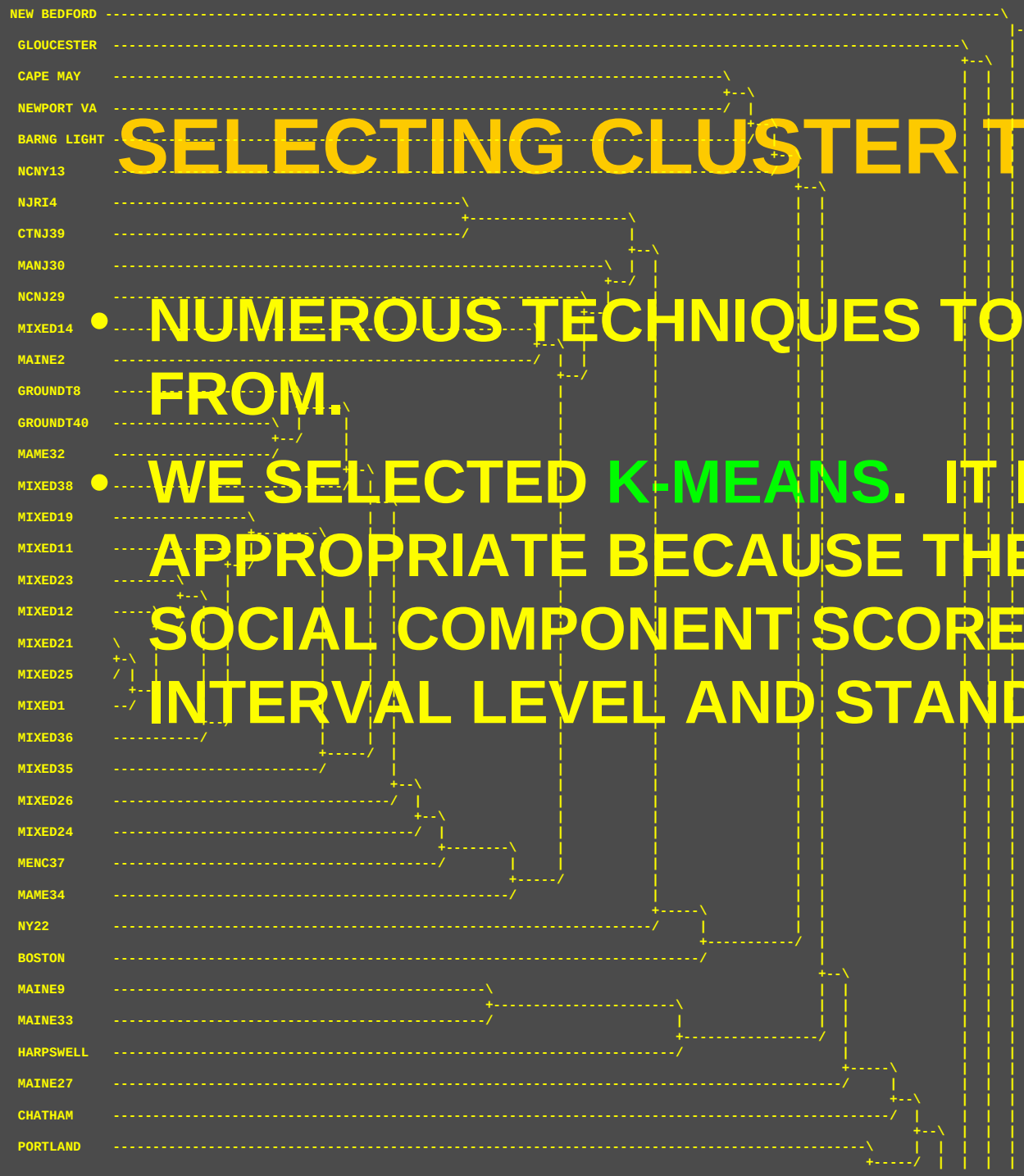
•Factor 2: Urban (- Urban percentage - Fishing occupation (-) – Tourist housing (-))

• Factor 3: Ethnic diversity (- Percentage Hispanic - Percentage other - Total population - Percentage Asian - Percentage white (-) - Pct. 2 or more races

COMPONENT SCORES CALCULATED FOR EACH OF THE 4 FISHERY AND 3 SOCIAL COMPONENTS: 7 COMPOSIT VARIABLES AS INPUT TO CLASSIFICATION

What’s Next?

- I could just show you slides with communities that scored highest and lowest on each component….
- Or I could try to group communities that manifested similar factor scores on each component.
- That is something like grouping organisms on basis of degree of presence on attributes like color, number of spots, eye location…. Etc etc



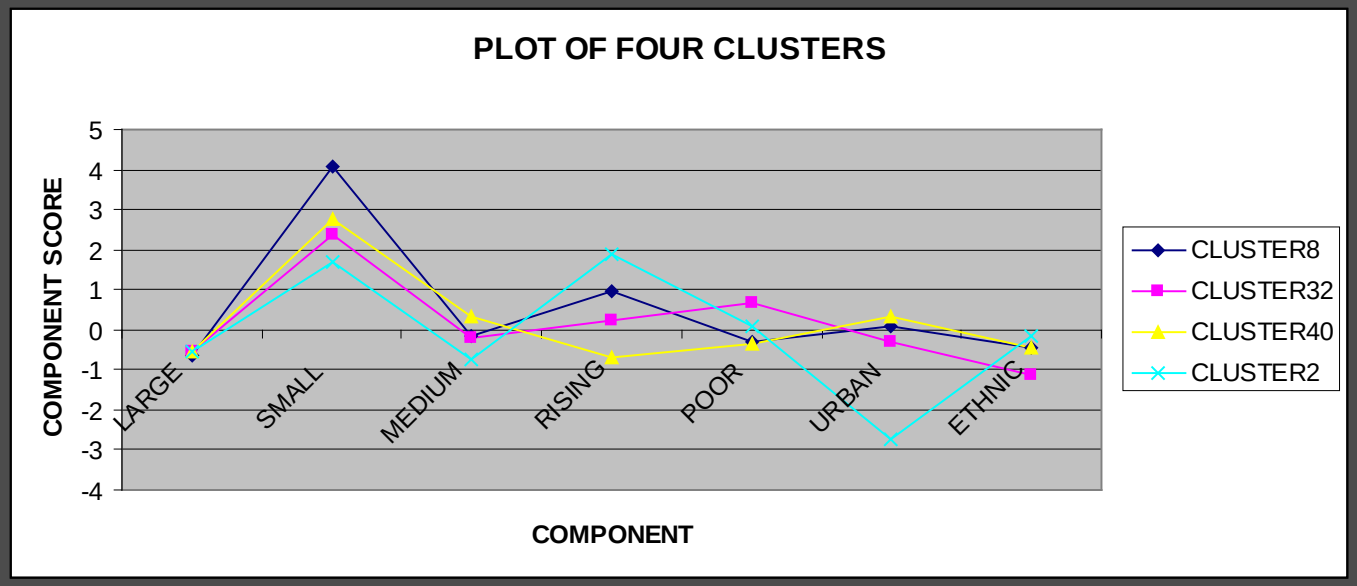
SELECTING CLUSTER TECHNIQUE

- NUMEROUS TECHNIQUES TO CHOOSE FROM.
- WE SELECTED K-MEANS. IT IS APPROPRIATE BECAUSE THE FISHERY & SOCIAL COMPONENT SCORES ARE INTERVAL LEVEL AND STANDARDIZED.

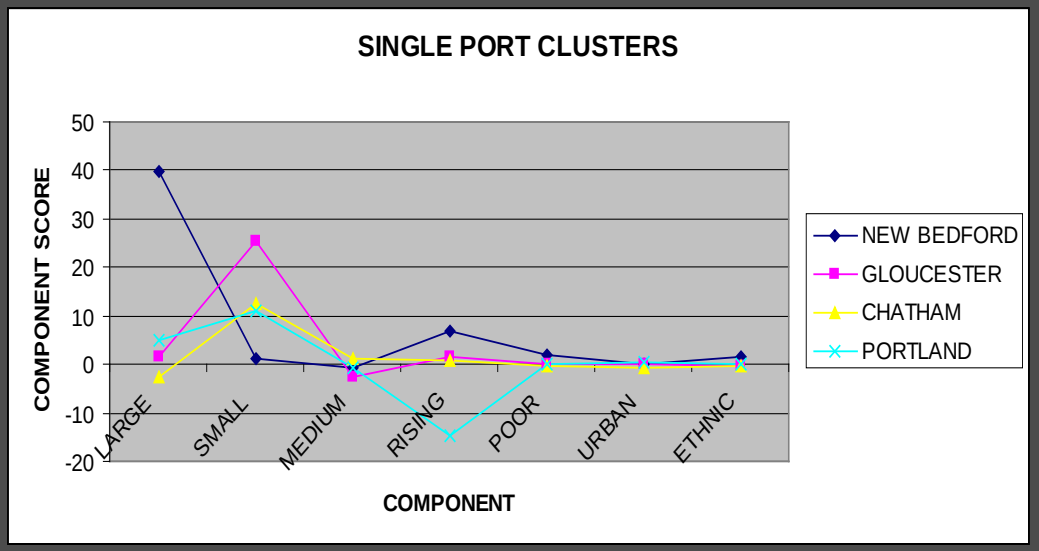
K-MEANS CLUSTER ANALYSIS

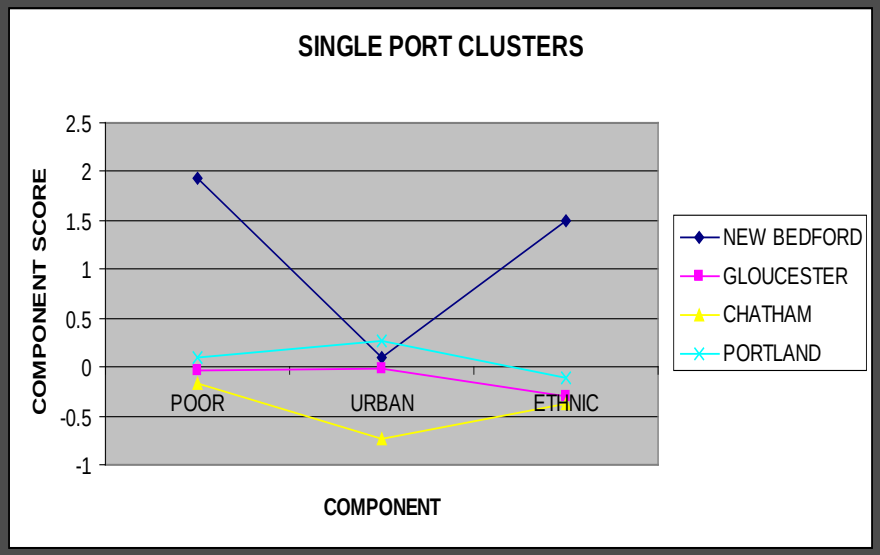
- 1ST YOU MUST DECIDE HOW MANY CLUSTERS TO PARTITION.
- WE SELECTED 40 (WHY?)
- THE PROCEDURE SELECTS “SEED” CASES, WHICH ARE MAXIMALLY SPREAD FROM THE CENTER OF ALL CASES.
- ALL CASES ARE ASSIGNED TO THE CLOSEST “SEED”
- CASES ARE THEN REASSIGNED TO MAXIMALLY REDUCE WITHIN-GROUPS SUM OF SQUARES

DIFFERENCES BETWEEN 4 SIMILAR CLUSTERS

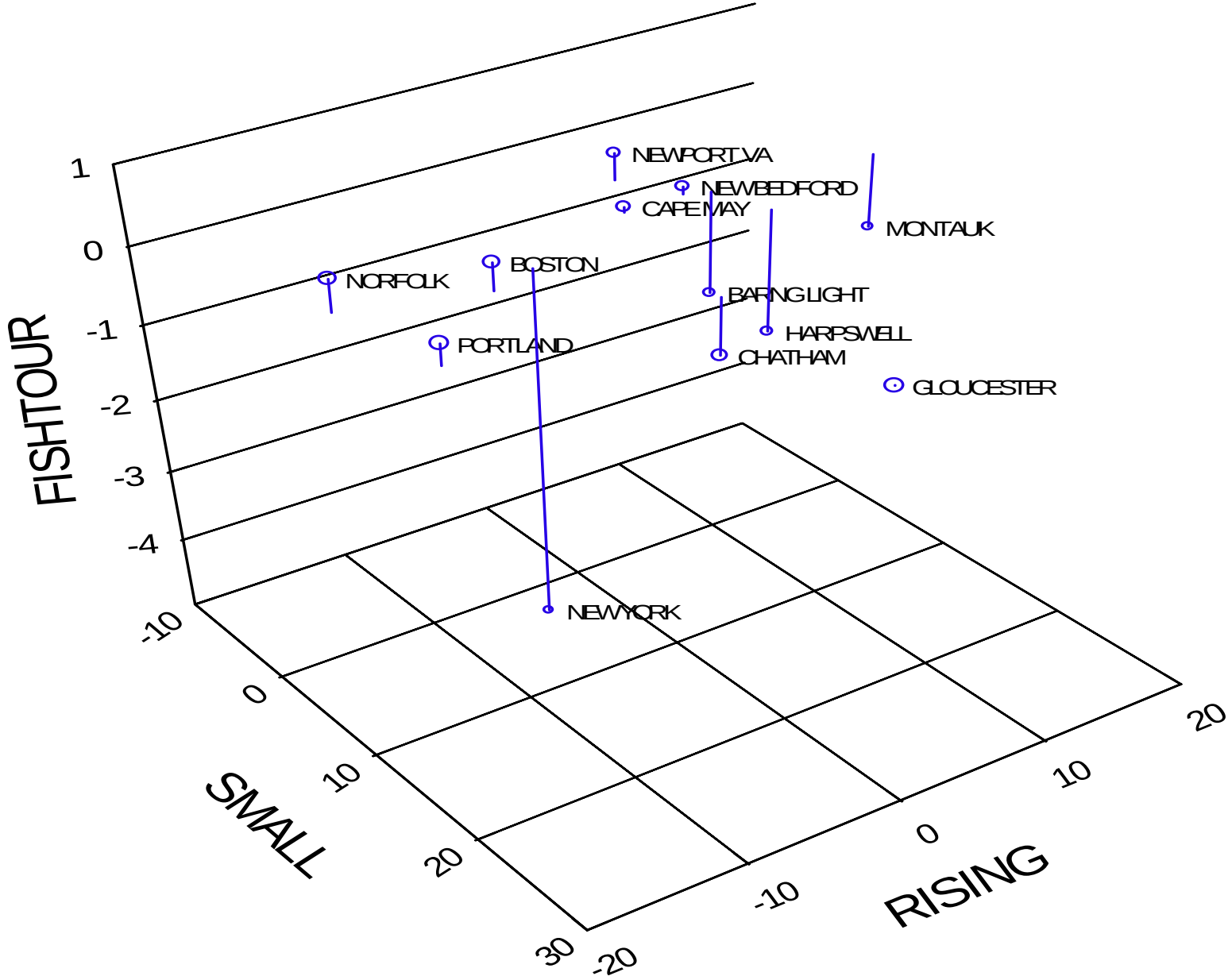


SOME SINGLE PORT CLUSTERS

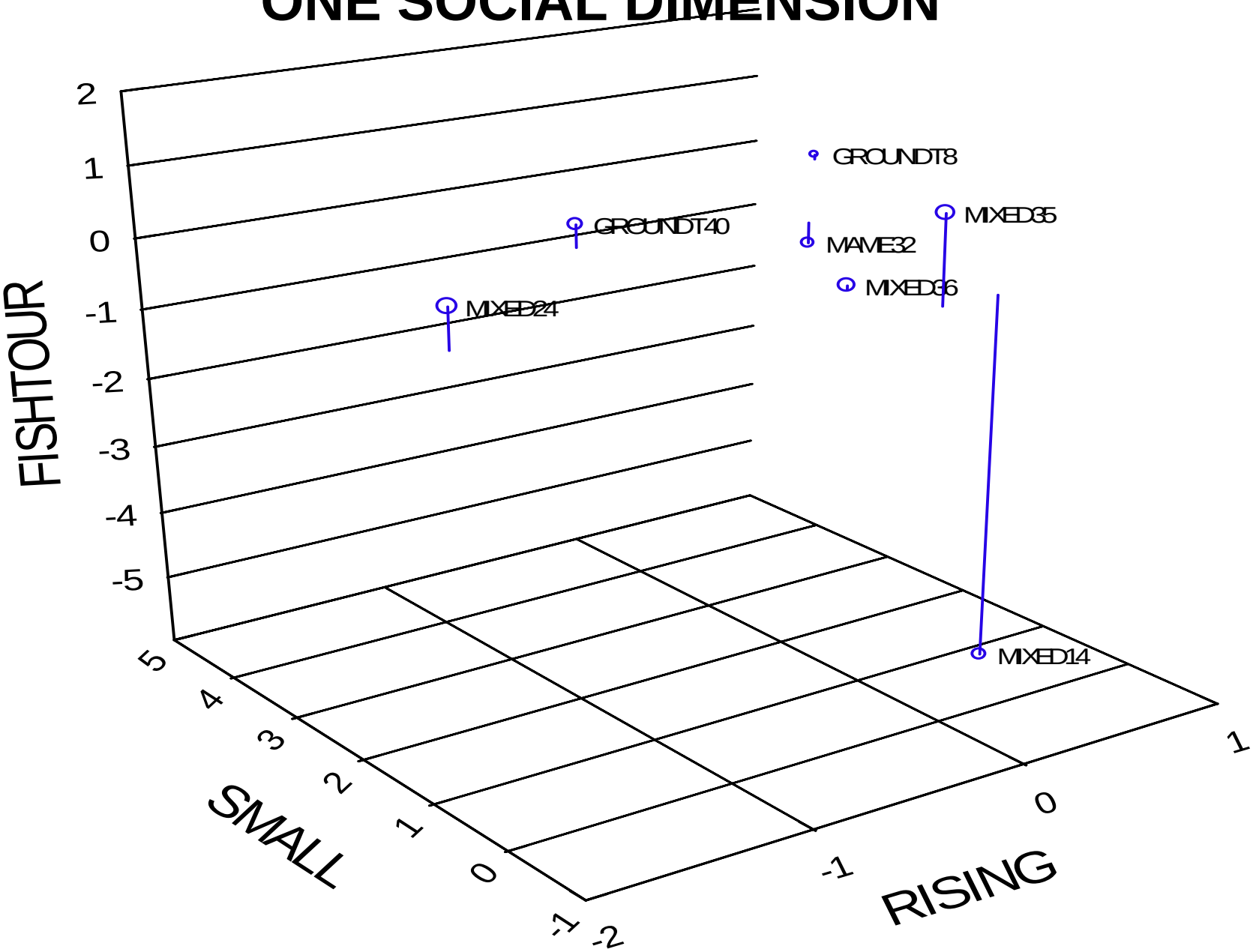




SINGLE PORT CLUSTERS IN 2 FISHING AND ONE SOCIAL DIMENSION



MULTIPLE PORT CLUSTERS IN 2 FISHING AND ONE SOCIAL DIMENSION



COMPARING CLUSTERS WITH PROFILE DATA (EXTERNAL VALIDITY)

- A DATA SET CONTAINING 11 “CULTURAL” VARIABLES FROM THE PROFILES WAS PREPARED.
- SCALES WERE CONSTRUCTED BY USING PRINCIPAL COMPONENT ANALYSIS WITH COMPONENT SCORES.

Principal component analysis of cultural and recreational fishing information from profiles

	Fishing Culture	Fishing Recreation
Fishermen's festival	0.667	0.258
Blessing of fleet	0.657	-0.001
Fishermen's memorial	0.619	-0.257
Fishermen's assistance	0.597	-0.314
Fishermen's competition	0.553	0.107
Fishermen's association	0.539	0.081
Recreational fishing pier	-0.090	0.718
Fishing tournament	-0.010	0.713
Fishing education	0.361	0.487
Percent variance	26.109	16.777

USING OUTPUT OF K-MEANS TO SELECT CASES FOR FURTHER EXAMINATION:

PROFILES, SURVEYS, ORAL HISTORY

Cluster 40

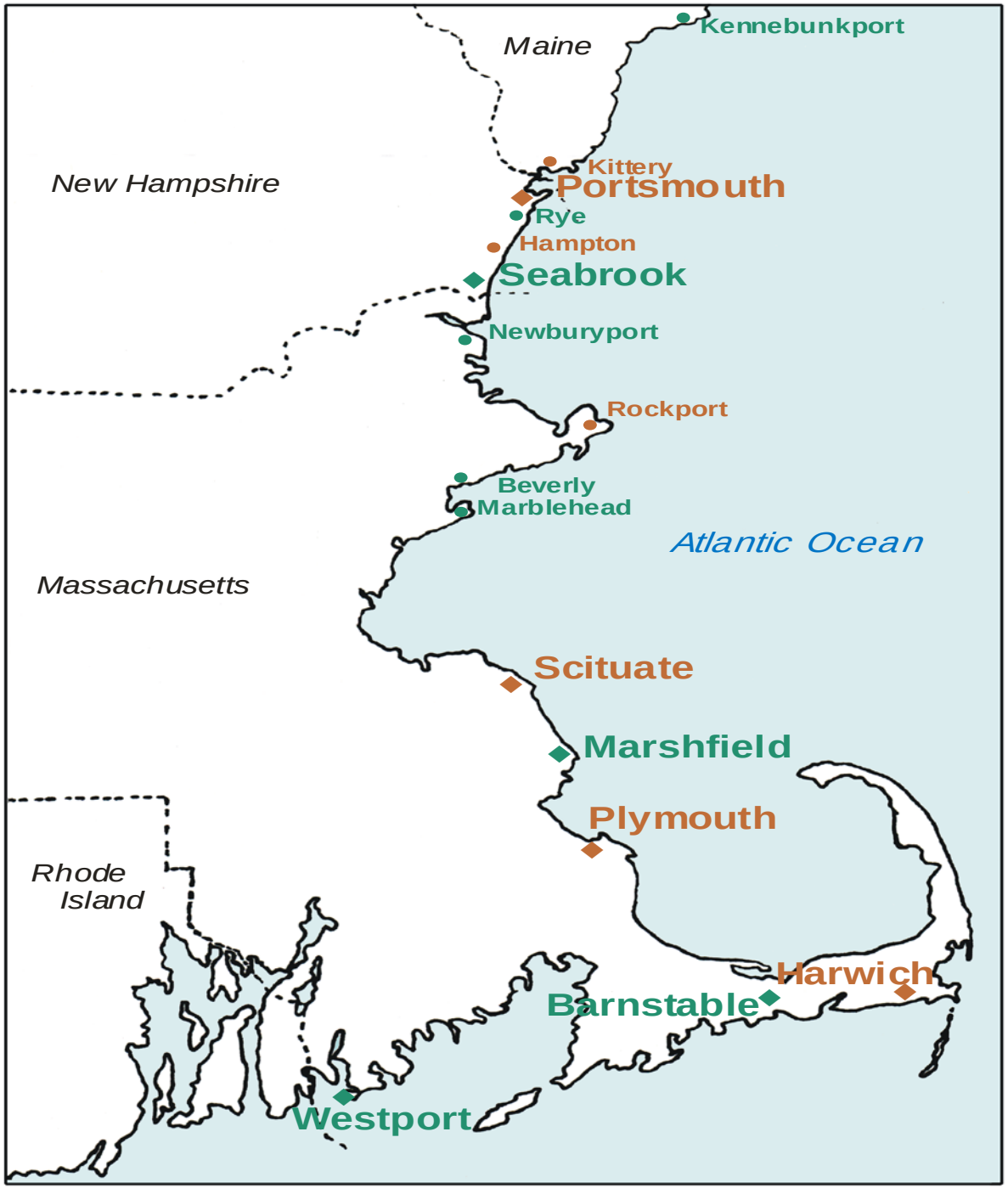
Members

Case	Distance
MA, Barnstable	0.29
MA, Westport	0.45
MA, Beverly	0.32
MA, Marblehead	0.52
MA, Newburyport	0.35
MA, Marshfield	0.37
ME, Kennebunkport	0.46
NH, Rye	0.35
NH, Seabrook	0.36

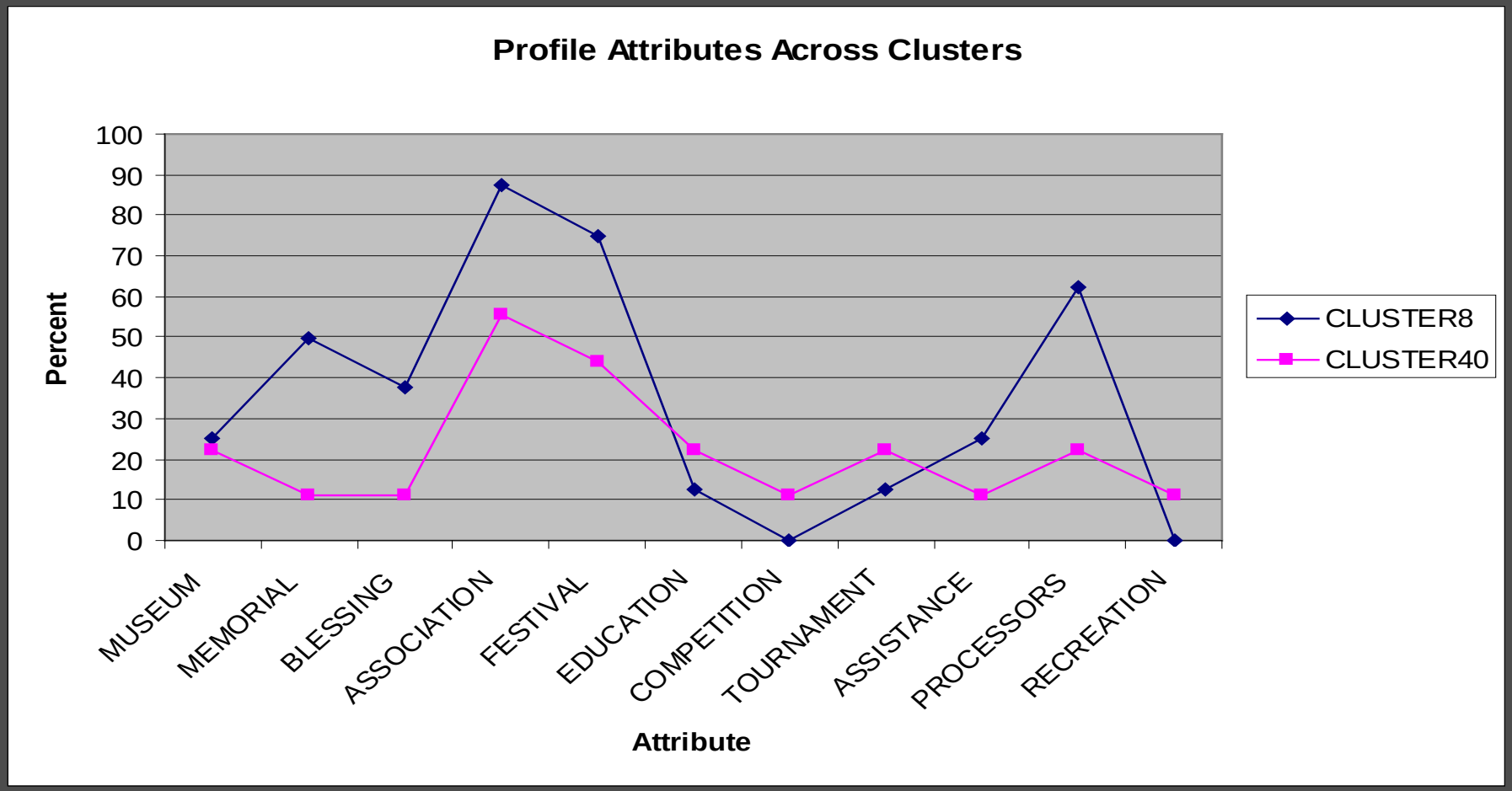
Cluster 8

Members

Case	Distance
MA, Harwich	0.51
MA, Rockport	0.34
MA, Plymouth	0.52
MA, Scituate	0.88
ME, Kittery	0.43
NH, Hampton	0.47
NH, Portsmouth	0.29


Maine
Kennebunkport
New Hampshire
Kittery
Portsmouth
Rye
Hampton
Seabrook
Newburyport
Rockport
Beverly
Marblehead
Atlantic Ocean
Massachusetts
Scituate
Marshfield
Plymouth
Rhode Island
Harwich
Barnstable
Westport

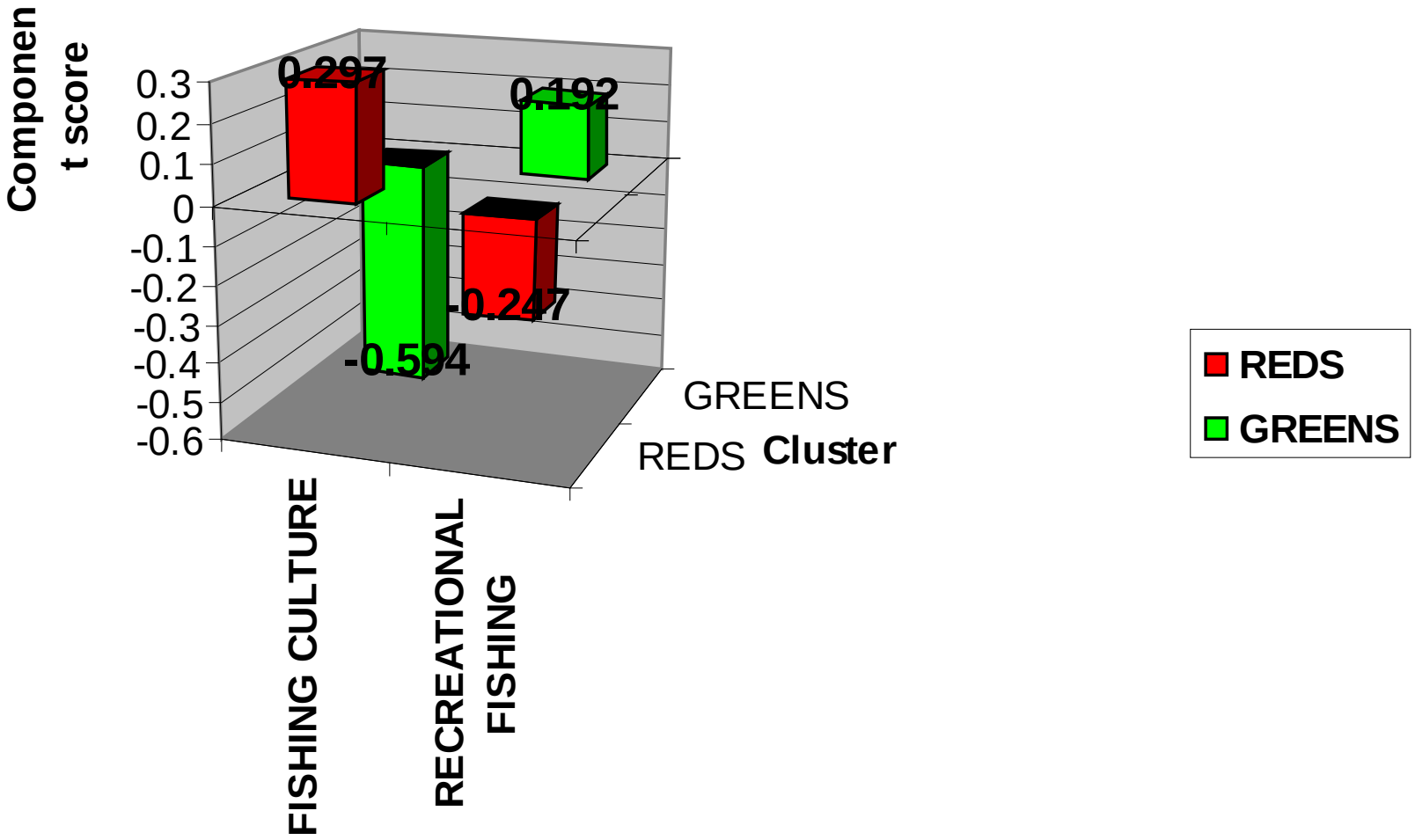
COMPARING INDIVIDUAL CULTURAL & RECREATIONAL ATTRIBUTES FROM PROFILES ACROSS THE 2 SIMILAR CLUSTERS (N=(9+8)=17)



A SEGMENT OF A HIERARCHICAL CLUSTER ANALYSIS OF THE 40 K-MEANS DERIVED CLUSTERS (REDS N=25, GREENS N=31)

```
GROUNDT8     -----------------------\
                                     +-----\
GROUNDT40    --------------------\   |     |
                                 +--/     |
MASS/MAINE32--------------------/         |
                                          +--\
MIXED38      ----------------------------/   |
                                             +--\
MIXED19      -----------------\               |  |
                              +--------\      |  |
MIXED11      --------------\   |        |     |  |
                           +--/        |     |  |
MIXED23      --------\     |           |     |  |
                     +--\  |           |     |  |
MIXED12      -----\   |  |  |           |     |  |
                  +--/  |  |           |     |  |
MIXED21      \    |     |  |           |     |  |
             +-\  |     |  |           |     |  |
MIXED25      / |  |     |  |           |     |  |
               +--/     |  |           |     |  |
MIXED1       --/        |  |           |     |  |
                        +--/           |     |  |
```

Testing clusters against profile data
Fishing culture (t=4.393, df=54, p<0.001)
Recreational (t=1.581, df=54, p>0.05)



So far……

- THE PROCEDURES USED CLUSTERED PORTS INTO GROUPS SIGNIFICANTLY DISTINGUISHABLE ON VARIABLES USED IN THE CLUSTER ANALYSIS.
- THE CLUSTERS ALSO DIFFER WITH REGARD TO OTHER "CULTURAL" VARIABLES FROM THE PROFILES.
- NOW, THE BIG TEST—GROUND TRUTHING THE TAXONOMY BY VISITING THE COMMUNITIES AND OBSERVING AND ASKING QUESTIONS…

Groundtruthing Methods

Photo-survey:

- **Infrastructure (e.g., dock areas, fish processing and marketing facilities, etc.)**
- **Fishing related cultural items (e.g., fishermen's memorials, museums, etc.)**
- **General snapshots to provide an overall picture of the ambience of the community**

Field validity checks:

- **Interviews with key informants concerning infrastructure and other points included in the profiles**

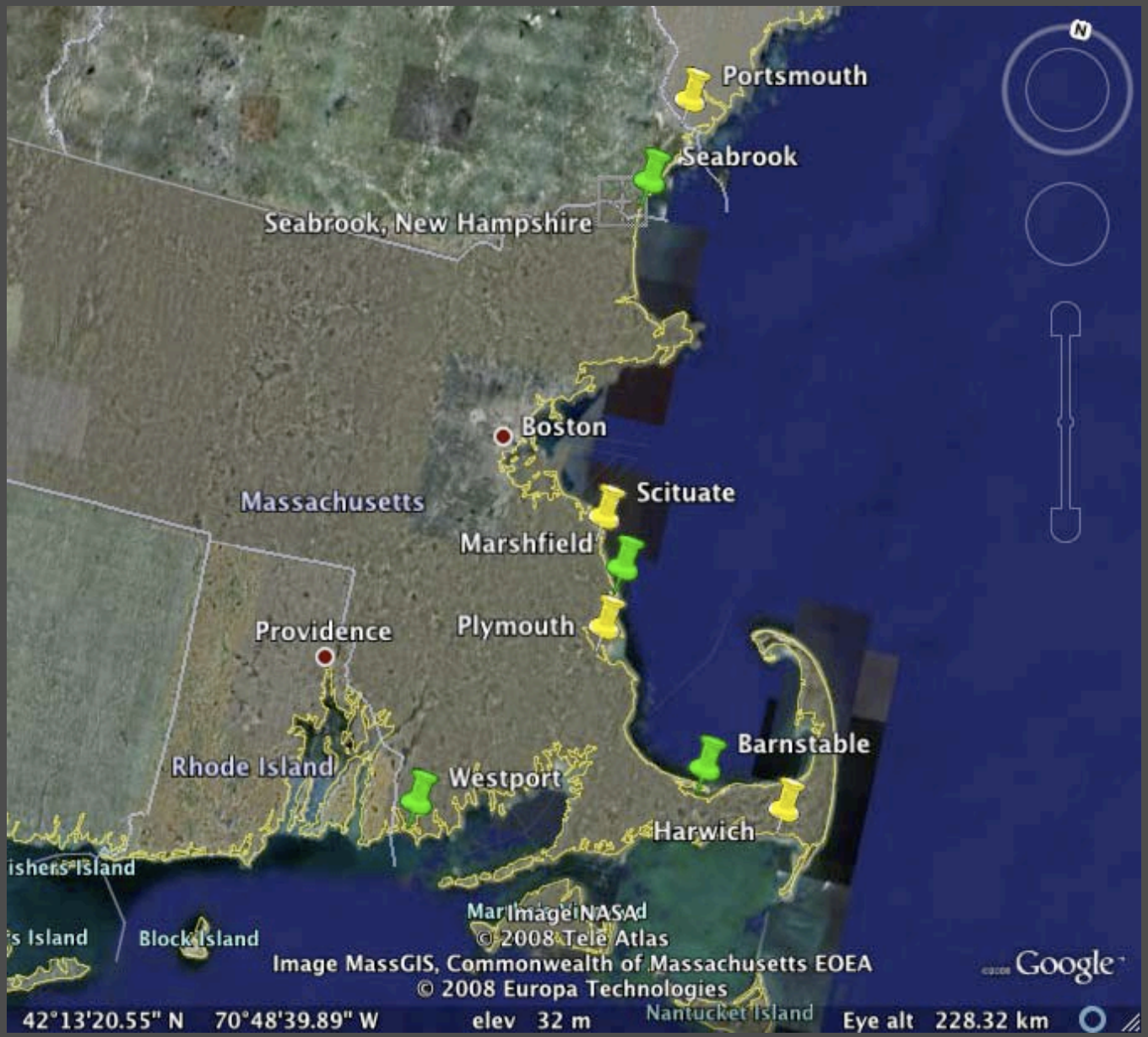
Groundtruthing of Profiles

- Internet-derived information in profiles was generally accurate
- Profiles did not capture some infrastructure and cultural attributes
- Groundtruthing can supplement web-based profiles

Groundtruthing of Cluster Analysis

- Are the communities in the clusters really different?
- Two clusters selected
  - Geographically overlapping
  - Statistically close (means on factor scores)
- Four communities in each
  - Cluster 40: Seabrook, NH; Westport, MA; Marshfield, MA; Barnstable, MA
  - Cluster 8: Plymouth, MA; Harwich, MA; Scituate, MA; Portsmouth, NH

CLUSTER 8 CLUSTER 40



Groundtruthing Methods II

- Brief survey including the following questions:
  - 1) If you were to list three things that characterize (community), what would they be?
  - 2) Would you say that (community) is a fishing community (if not included in the response to the first question)?
  - 3) What are 3 important issues facing (community) today?
  - 4) Has (community) changed over the past 5-10 years? How?
  - 5) Would you advise a young person to live in (community)? Why?

- Surveyed 170 residents in eight cities/towns

Clustered Communities

- Communities within the two clusters did appear distinct
  - Communities have a different “feel”
  - Cluster 8 communities “nicer”, friendlier, more cohesive
  - Cluster 40 communities were towns made up of several villages, with one distinct fishing area
- Differences are small, in the details
  - Many differences not statistically significant
  - Clusters were close, so communities should be similar

Community divisions

- Chi-square test - cluster x description "different parts" or "spread out"
- $\chi^2 = 5.505$, $p<.05$
  - Cluster 40: 11.1%, Cluster 8: 2.2%
- Respondents from communities in Cluster 40 were more likely to refer to different sections or villages of the community

Gentrification

- In both clusters, many residents described gentrification as an issue or change
  - Gentrification = “more condos”, “million dollar homes being built”, “loss of character”, “yuppy”
- Chi-square test - cluster x dichotomous gentrification variable
- $\chi^2 = 13.175$, $p<.001$
  - Cluster 40: 19.8%; Cluster 8: 46.1%

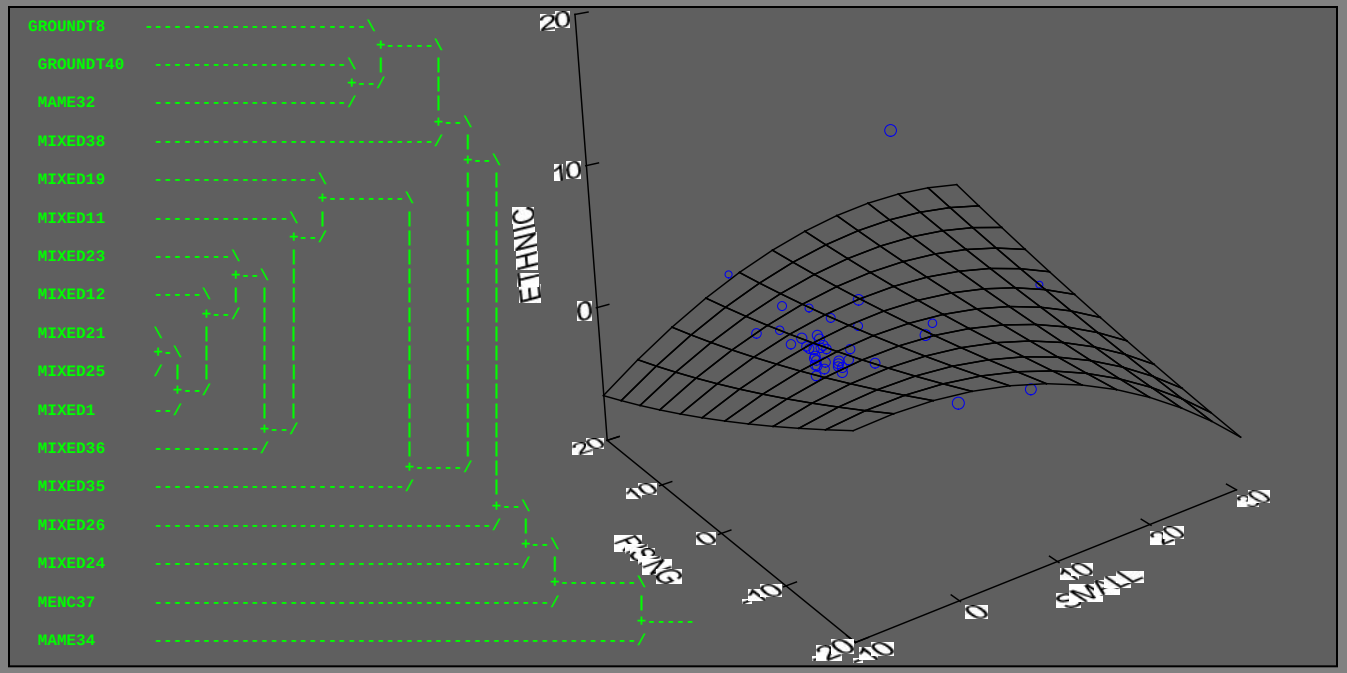
Respondents in Cluster 8 were more likely to name gentrification as an issue or change

-communities in these clusters may be differentially impacted by gentrification

CONCLUSION

- Cluster analysis did give clusters that seem to be different
- One cluster demonstrated more “social solidarity”, but also more gentrification
- Differences may only be apparent upon groundtruthing communities
- Cluster analysis appears to be effective method of determining representative communities for in-depth analysis

NUMERIC TAXONOMY OF FISHING TYPES



THE PROBLEM

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A POTENTIAL SOLUTION

- IF WE COULD CLASSIFY OR TYPE THESE ESTIMATED 5000 BOATS INTO SMALLER GROUPINGS, SOCIAL IMPACT ANALYSIS DATA FROM A SAMPLE WITHIN WITHIN EACH GROUP WOULD PROVIDE BETTER PREPARATION FOR DECISION MAKING.
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THE DATABASE
ALL STAGES REQUIRE DECISIONS

- Data analyzed are 2009 landings data, by permit, for the North East Region (N=5428).
- Thirty-two types (including a mixed “other”) category were available for analysis. Of the 5428 cases only 3236 manifested landings for the year 2009 and are identified as “active permits.”
- Only the active permits are used in the analysis.

Three basic processes tested for identification of fishing types

- 1) principal component analysis of raw landings data with factor scores calculated for each active permit
- 2) principal component analysis of log landings data with factor scores calculated for each active permit
- 3) hierarchical (average linkage method) cluster analysis of types, using Pearson's correlation coefficient as the distance metric, with cluster scores for each permit based on log sum of landings within each cluster.

Principal component analysis of raw landings data with factor scores calculated for each active permit

- **With eigen value = 1 for cut-off & varimax rotation 13 components result (**66 percent of the variance in the data set).
- **The types combined in the fisheries identified by the components make sense (e.g., the first 3 and 5th components made up of mostly deep water fish, but all targeted by trawl nets. The 4th component includes pelagics like mackerel and herring, and so on.**

Problem with PC and eigen value cut off of 1

- Some components have only one highly loading type, a phenomena usually avoided by analysts who use PCA as a data reduction technique.
- Solution—use scree-test.
- Result: 9 components (54% variance), which make sense. Fisheries identified make sense, and the types that are not included in a component can be evaluated as separate fisheries.

Principal Component Analysis of Log Data

- many of the types are strongly skewed to the right. A log transformation would improve the reliability of correlations used in PCA and reduce importance of size of landing from the cluster analysis
- To facilitate a cleaner analysis, shrimp, red crab and clams were not used in the PCA & number of components to be rotated was set at 5 (based on scree test). The PCA accounts for 64 percent of the variance, and the structure is relatively clear.

Component scores and K-means cluster analysis of log data

- the results are again unsatisfactory --the largest cluster (cluster 1 with 1578 cases) contains almost one-half the cases & still seems to be based on amount of landings (size).
- the PCA analyses appear to do an excellent job of identifying co-occurring species in landings over the year
- But the calculation of component scores seems to be inappropriate for our purposes

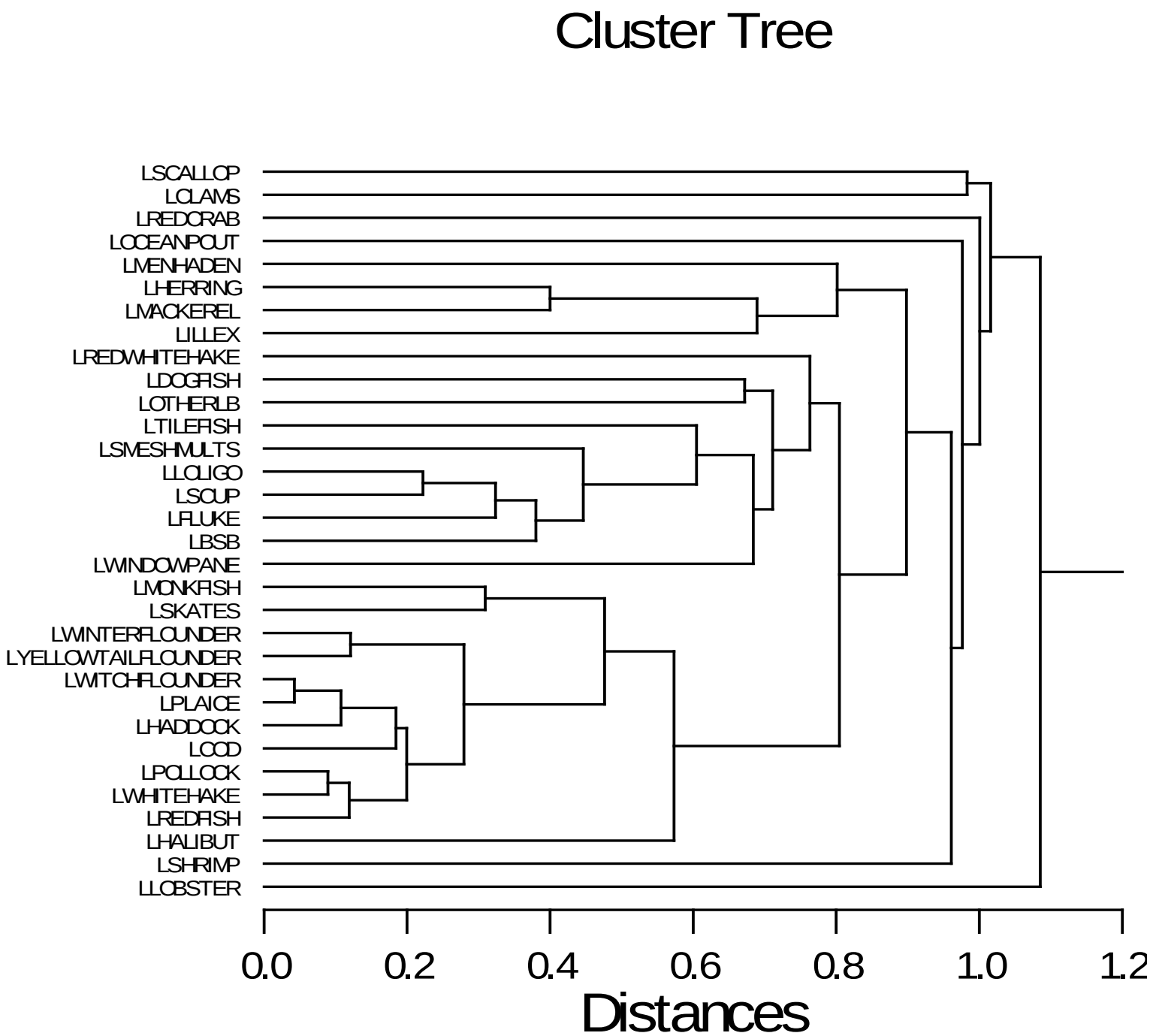
Problem with component scores

- calculated using weights derived from the PCA analysis
- each type contributes to the score for each permit
- This can result in a score that does not clearly define the landings—it has “fuzzy edges.”

Hierarchical Cluster Analysis of Log Data

- cluster analysis of log landing types, using Pearson’s correlation coefficient as the distance metric

Figure 3. Hierarchical cluster analysis of log permit landing data.



Hierarchical Cluster Analysis of Log Data

- closely parallels the various PCAs
- Similar types are combined at various branchings (distances) in the resulting tree
- co-occurring types can be conceptualized as indicating separate fisheries as with the PCA analyses
- we treat scallops, clams, red crab, ocean pout, shrimp and lobster as separate fisheries

Hierarchical Cluster Analysis of Log Data II

- We group menhaden, herring, mackerel, illex as a fishery.
- Loligo and scup are combined with fluke, then black sea bass. This grouping is then combined with small mesh mullets, then tilefish. This larger grouping is combined with dogfish and “mixed others” and finally red-white hake to form the second multi-type fishery identified by the hierarchical cluster analysis.
- The third multi-type fishery is characterized by closer distances—similar to the PCA analyses

Hierarchical Cluster Analysis of Log Data II

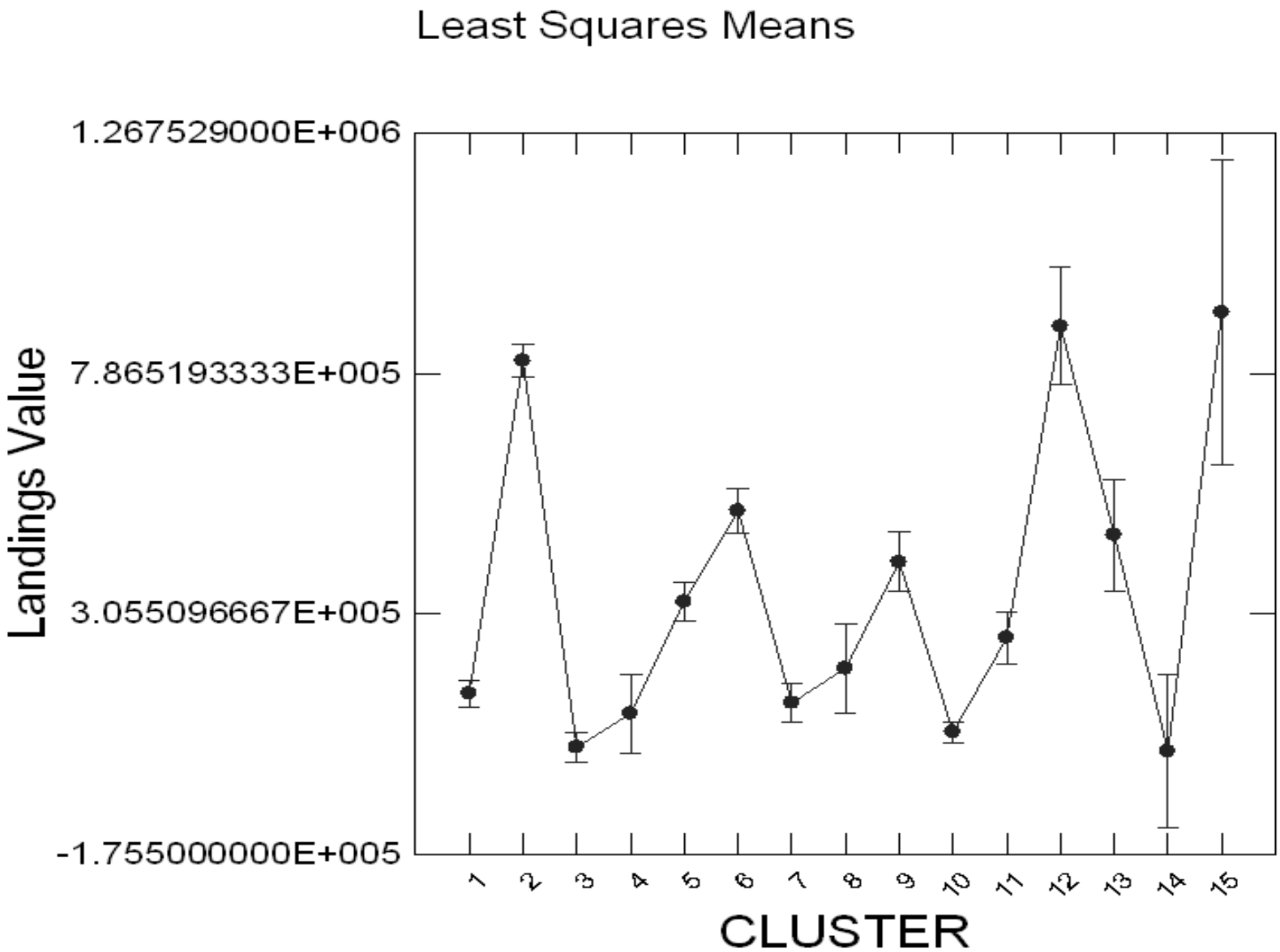
- The tightest cluster includes pollock, white hake and redfish.
- This group is then combined with another tight cluster including witch flounder, haddock, plaice and cod.
- This larger cluster is then combined with the other flounders—winter flounder and yellow tail flounder.
- Monkfish and skates are then combined into the cluster, and finally, at the greatest distance halibut is included in this 3rd cluster.

Cluster scores and clustering boats into the types

- Cluster scores are calculated for each active permit by logging summed landings for each of the 9 fisheries defined by the hierarchical cluster analysis
- Permits (boats) are clustered using K-means cluster analysis of the cluster scores to develop a taxonomy of boats (permit holders) based on similar levels of participation in the fisheries identified by the hierarchical cluster analysis.

CLUSTER(rows) by PPST$(columns)

	CT	DE	FL	GA	MA	MD	ME	NC	NE	NH	NJ	NY	PA	RI	VA	Tot.
1	3	1	0	0	73	1	339	2	0	11	11	10	0	57	1	509
2	11	0	2	2	160	13	18	12	0	2	92	3	0	5	33	353
3	2	1	1	0	144	13	28	50	0	3	40	76	1	27	30	416
4	0	0	0	0	2	0	58	0	0	0	0	0	0	0	0	60
5	0	1	0	0	164	0	40	0	0	11	3	7	0	14	1	241
6	1	0	0	0	24	2	2	39	0	0	62	17	1	3	35	186
7	10	0	0	0	105	3	10	9	0	13	39	30	0	36	5	260
8	0	0	0	0	5	0	27	0	0	15	0	0	0	0	0	47
9	4	1	0	0	15	1	0	2	0	2	14	24	0	41	0	104
10	8	0	0	0	195	0	572	0	0	31	15	1	0	24	1	847
11	1	0	1	0	48	1	35	0	0	8	23	10	0	7	2	136
12	0	0	0	0	12	0	8	0	1	2	4	0	0	0	0	27
13	0	0	0	0	3	2	2	3	0	0	9	3	0	3	5	30
14	0	0	0	0	0	0	15	0	0	1	0	0	0	0	0	16
15	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	4
Total	40	4	4	2	952	36	1,156	117	1	99	312	181	2	217	113	3,236


Least Squares Means
1.267529000E+006
7.865193333E+005
3.055096667E+005
-1.755000000E+005
Landings Value
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
CLUSTER

Conclusions

- Overall, this procedure appeared to provide the most useful results—no huge clusters & clusters of permit holders do make sense.
- The future…….
- Looking at changes through time
- Relating to gear types & income
- Other……..