

# Some slides for the discussion on multispecies analyses and considerations.

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# EBFM (NMFS, 2016)

*“A systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals”*

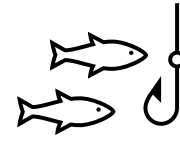
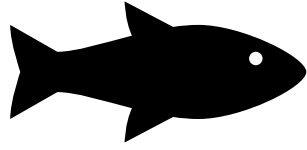


Different meanings (8) and **different principles** (at least 10) (Link and Markshak, 2021)



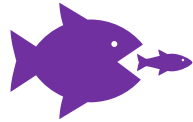
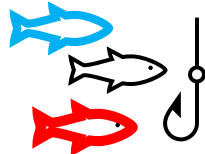
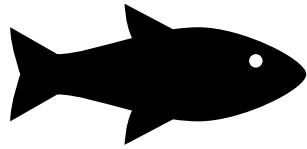
***Moving beyond a single species approach***

SSF



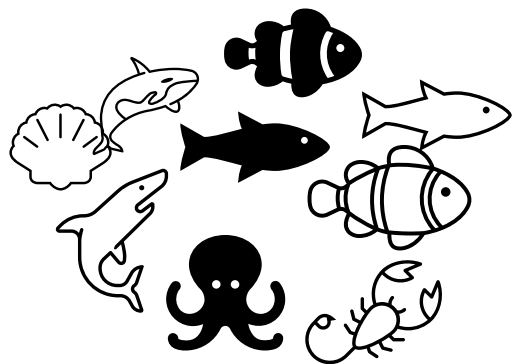
FMP

EAFM



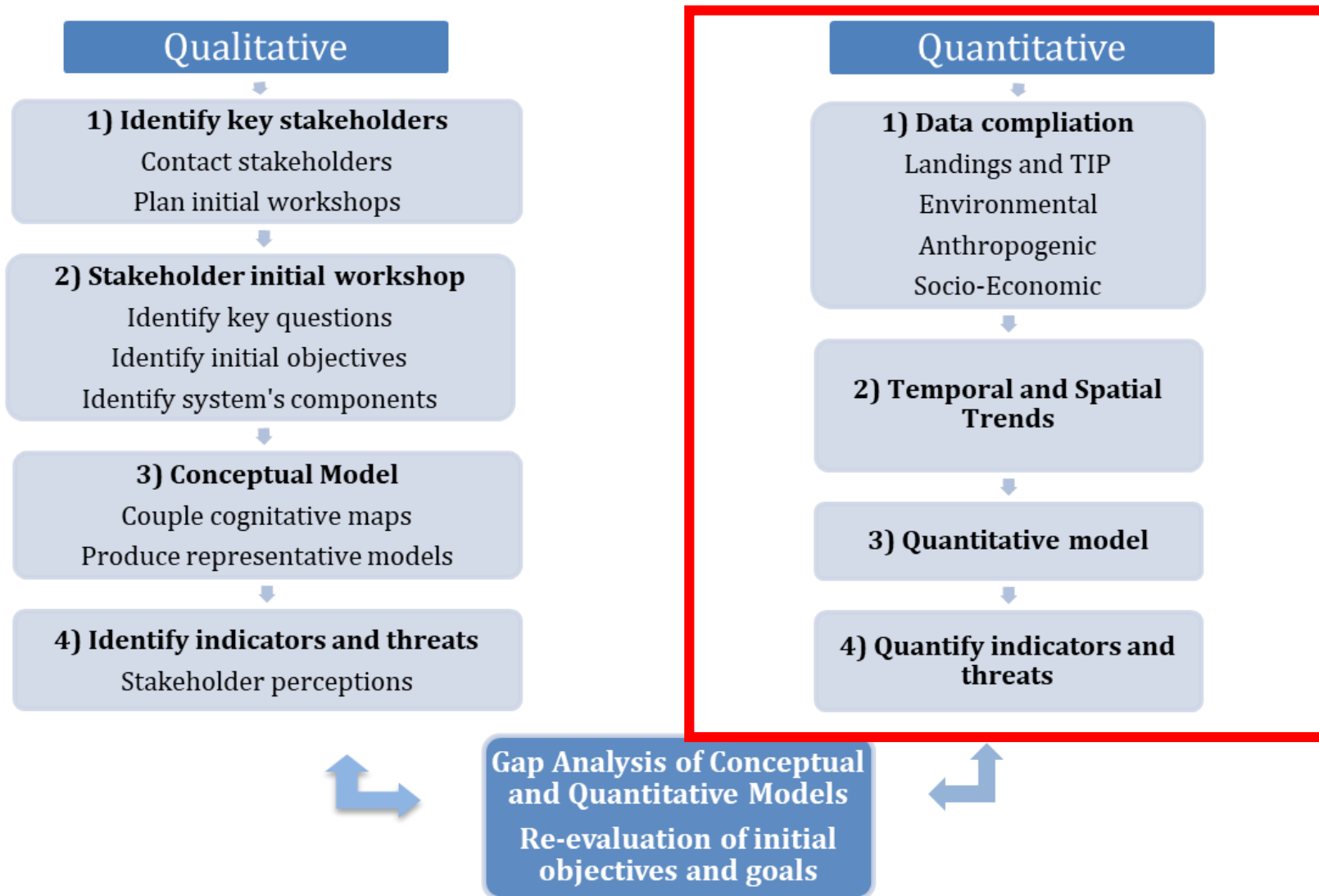
FMP

EBFM



EFP

# Where are We Now?: Description of the Fisheries System



# Quantitative Approach

## Data Collection

### Fishery Independent

NCRMP

PRCRMP

USVI CRMP

SEAMAP

CRES

### Fishery Dependent

PR DRNA

USVI DPNR

Landings

TIP

### Env/Anthrop

Oceanographic features

Disturbances

Rainfall

Connectivity

Habitat features

Anthropogenic

### Socio-Economic

CSVI

\*Fishery Engagement and  
Reliance

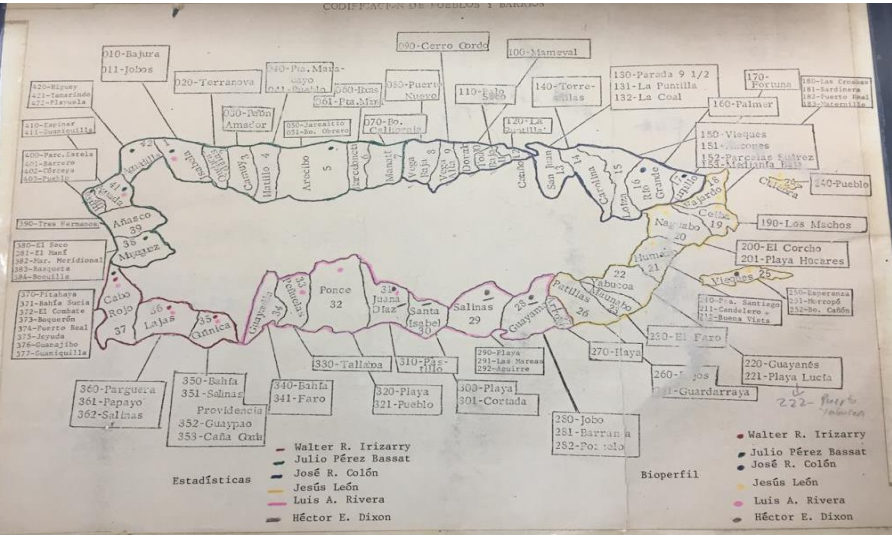
\*Social Vulnerability

Post disturbance  
assessments

Coral reef dependency

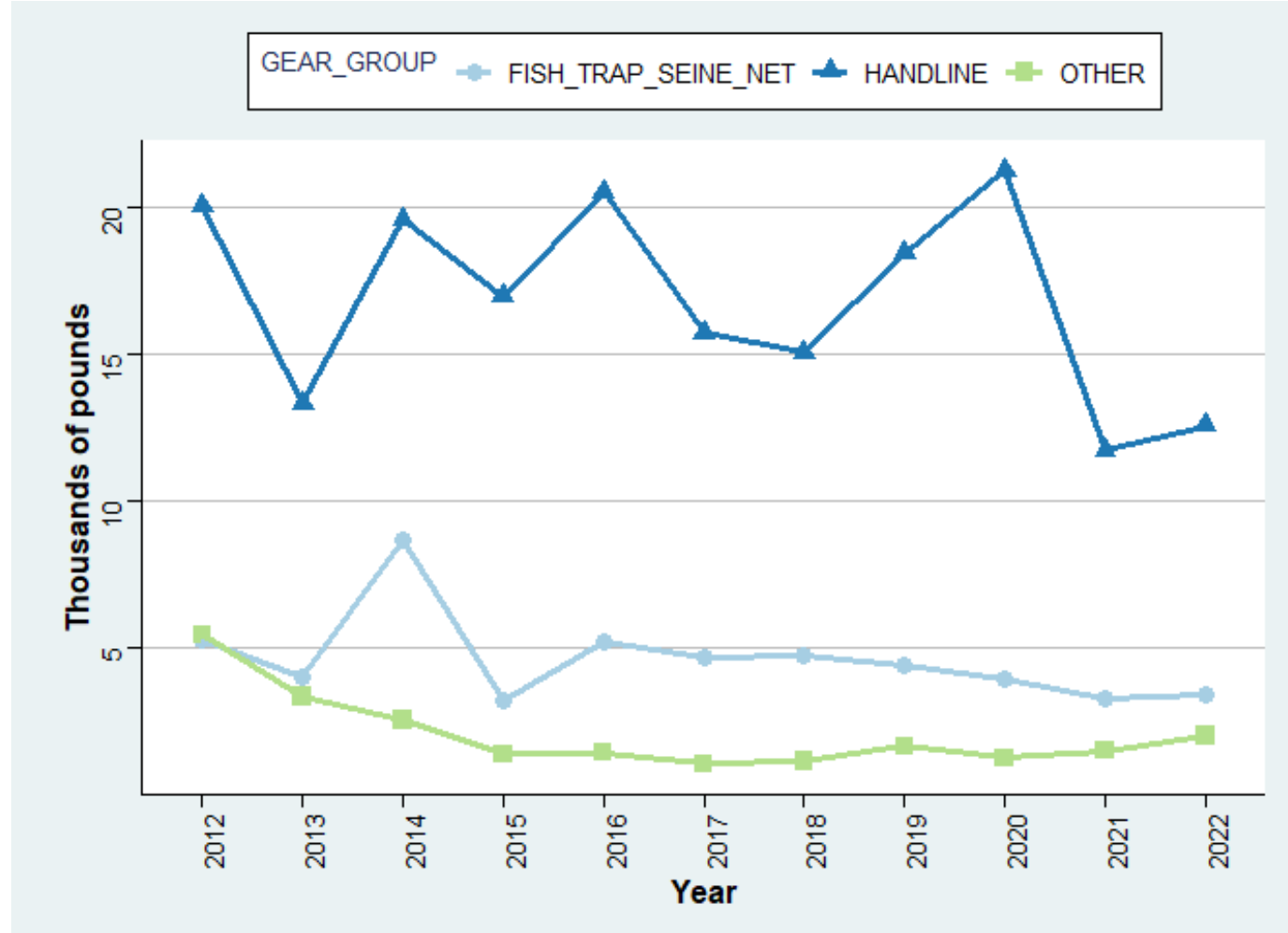
Fishery Census Data

Landings data (SEFSC):  
Response variable (Biomass)  
1983 -2020  
NCE = 28%



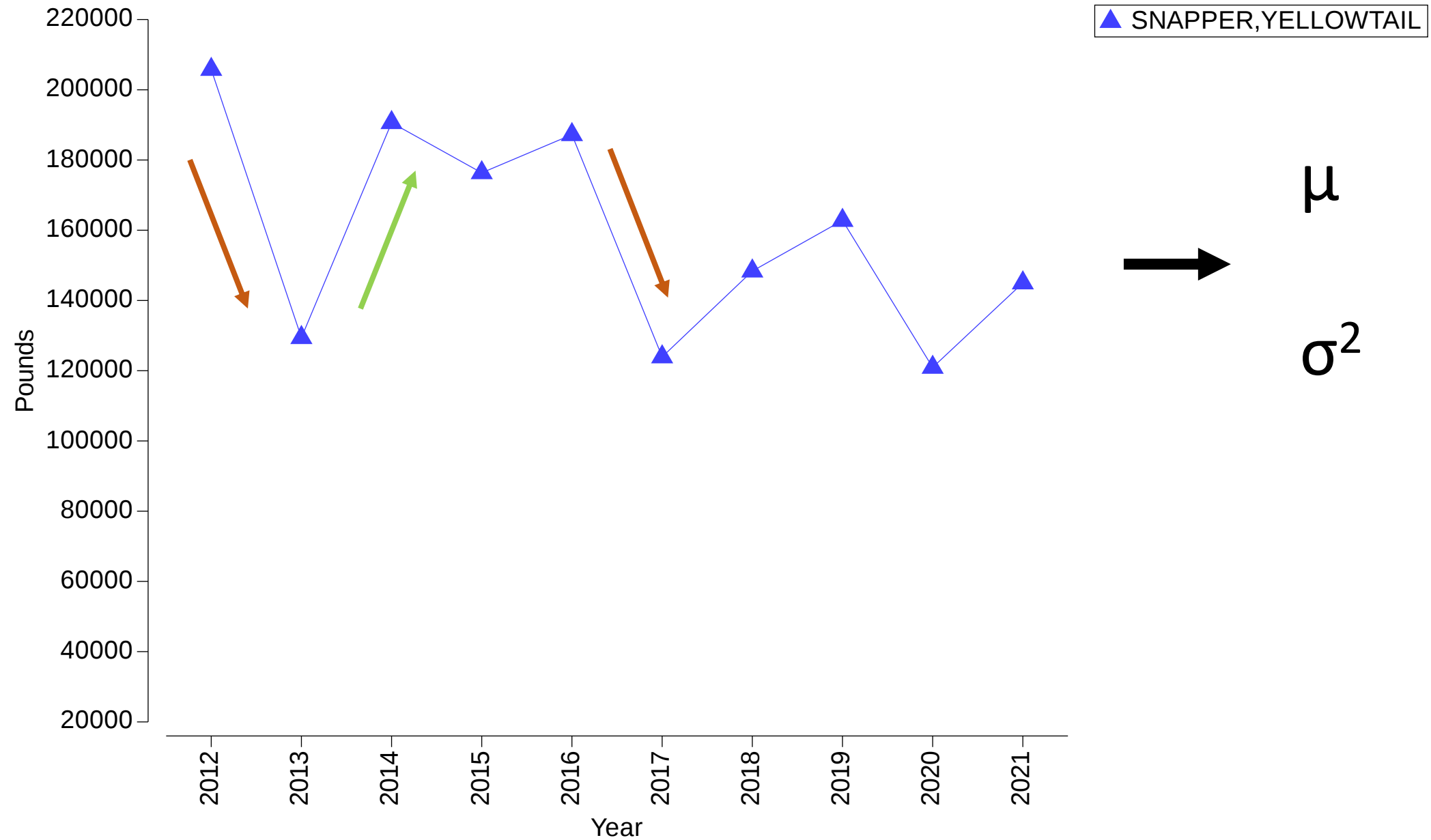
| TUNA AND   |             |                |                    |                      |                     |               |                 |               |                     | SNAPPER,       |                      |             |      |         |          |                               |
|------------|-------------|----------------|--------------------|----------------------|---------------------|---------------|-----------------|---------------|---------------------|----------------|----------------------|-------------|------|---------|----------|-------------------------------|
| BARRACUDA  | JACKS       | MACKEREL, KING | PORGY, UNSPECIFIED | MACKERELS, UNSPECIFI | GROUPE, UNSPECIFIED | SNAPPER, LANE | SNAPPER, MUTTON | SNAPPER, SILK | SNAPPER, YELLOWTAIL | OBSTERS, SPINY | SNAPPER, UNSPECIFIED |             | YEAR | REGION  | LOCATION | GEAR                          |
| S1         | 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                    |             | 1983 | PR-East | CEIBA    | HAUL SEINES                   |
| S3         | 0           | 0              | 0                  | 906.557377           | 0                   | 1732.786885   | 627.868852      | 88.5245902    | 0                   | 1345.90164     | 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           |             | 1983 | PR-East | CEIBA    | POTS AND TRAPS, FISH          |
| S5         | 0           | 0              | 108.196721         | 0                    | 0                   | 0             | 0               | 0             | 0                   | 0              | 0                    |             | 1983 | PR-East | CEIBA    | TROLL LINES                   |
| S6         | 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                    |             | 1983 | PR-East | CULEBRA  | HOOK AND LINE, BOTTOM         |
| S8         | 0           | 0              | 0                  | 0                    | 0                   | 1632.786885   | 122.95082       | 106.557377    | 0                   | 1062.29508     | 0                    |             | 1983 | PR-East | CULEBRA  | POTS AND TRAPS, FISH          |
| S9         | 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                    |             | 1983 | PR-East | CULEBRA  | TROLL LINES                   |
| S11        | 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                    |             | 1983 | PR-East | FAJARDO  | GILL NETS, OTHER              |
| S13        | 1290.163934 | 0              | 278.688525         | 0                    | 0                   | 0             | 0               | 19.6721311    | 0                   | 647.540984     | 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                    |             | 1983 | PR-East | FAJARDO  | HOOK AND LINE, BOTTOM         |
| S15        | 0           | 0              | 0                  | 0                    | 0                   | 62.29508197   | 103.278689      | 65.5737705    | 0                   | 50.8196721     | 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                    |             | 1983 | PR-East | FAJARDO  | TROLL LINES                   |
| S18        | 0           | 0              | 0                  | 0                    | 0                   | 18.03278689   | 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                    |             | 1983 | PR-East | HUMACAO  | CAST NETS                     |
| S20        | 0           | 0              | 0                  | 0                    | 0                   | 0             | 386.885246      | 0             | 0                   | 0              | 0                    |             | 1983 | PR-East | HUMACAO  | GILL NETS, OTHER              |
| S21        | 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        | obster               | Snapper     |      |         |          |                               |

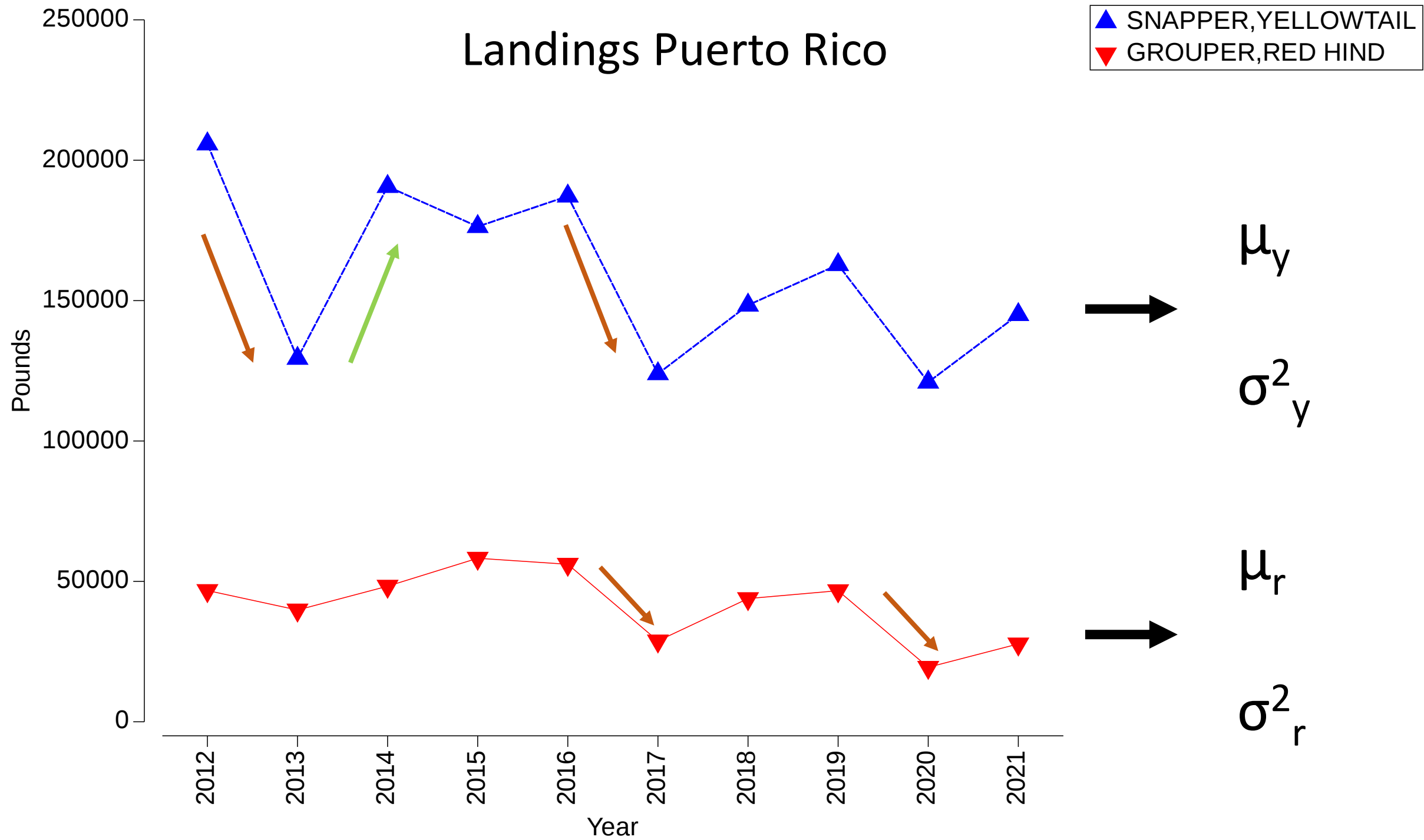
# Working paper SEDAR 84



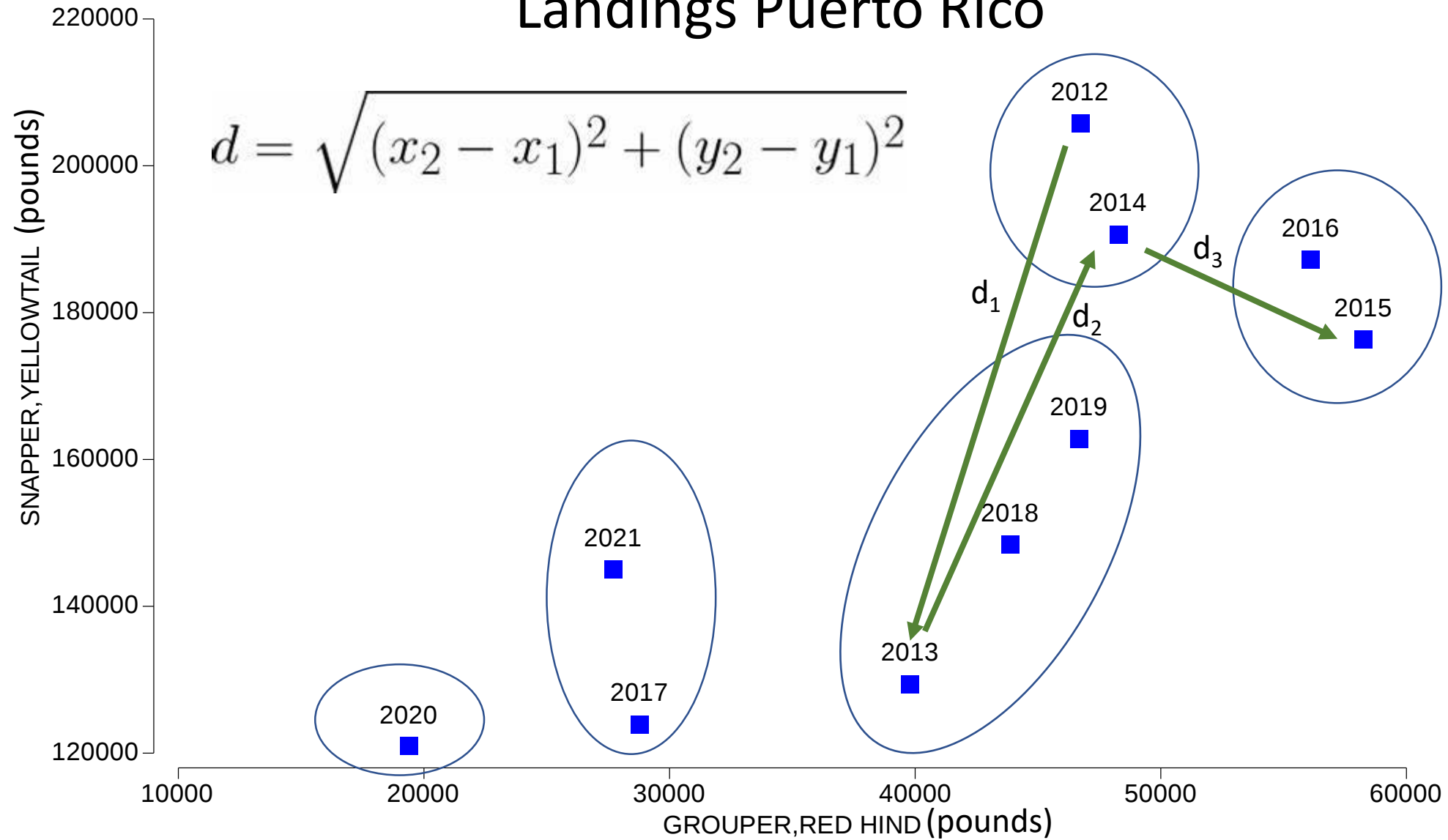
Martínez Rivera, Stephanie, Kimberley Johnson, and M. Refik Orhun. 2024. SEDAR 84 Commercial fishery landings of Yellowtail Snapper (*Ocyurus chrysurus*) in St. Thomas and St. John, US Caribbean, 2012-2022. SEDAR84-WP-02. SEDAR, North Charleston, SC. 15 pp.

# Landings Puerto Rico

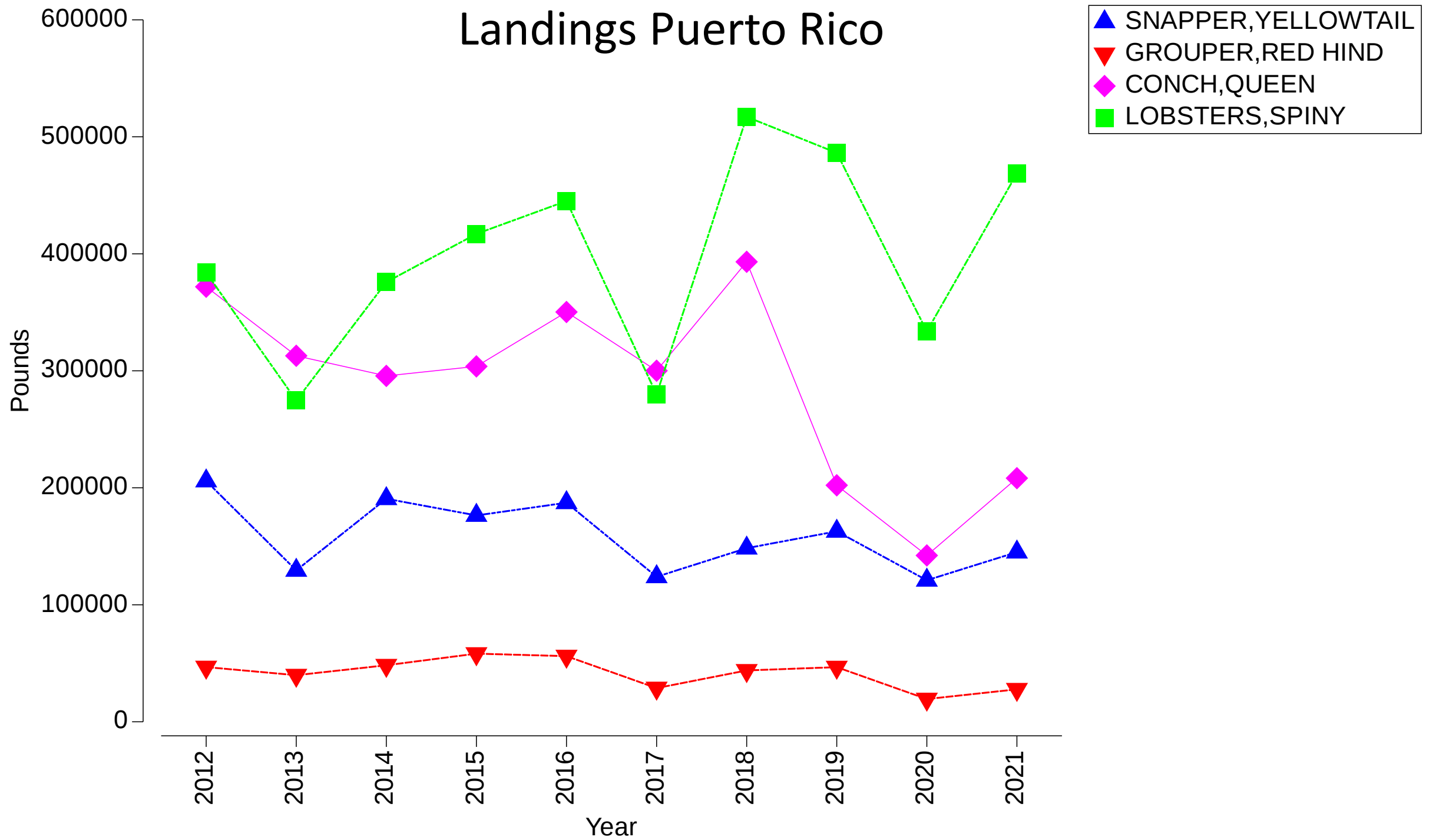




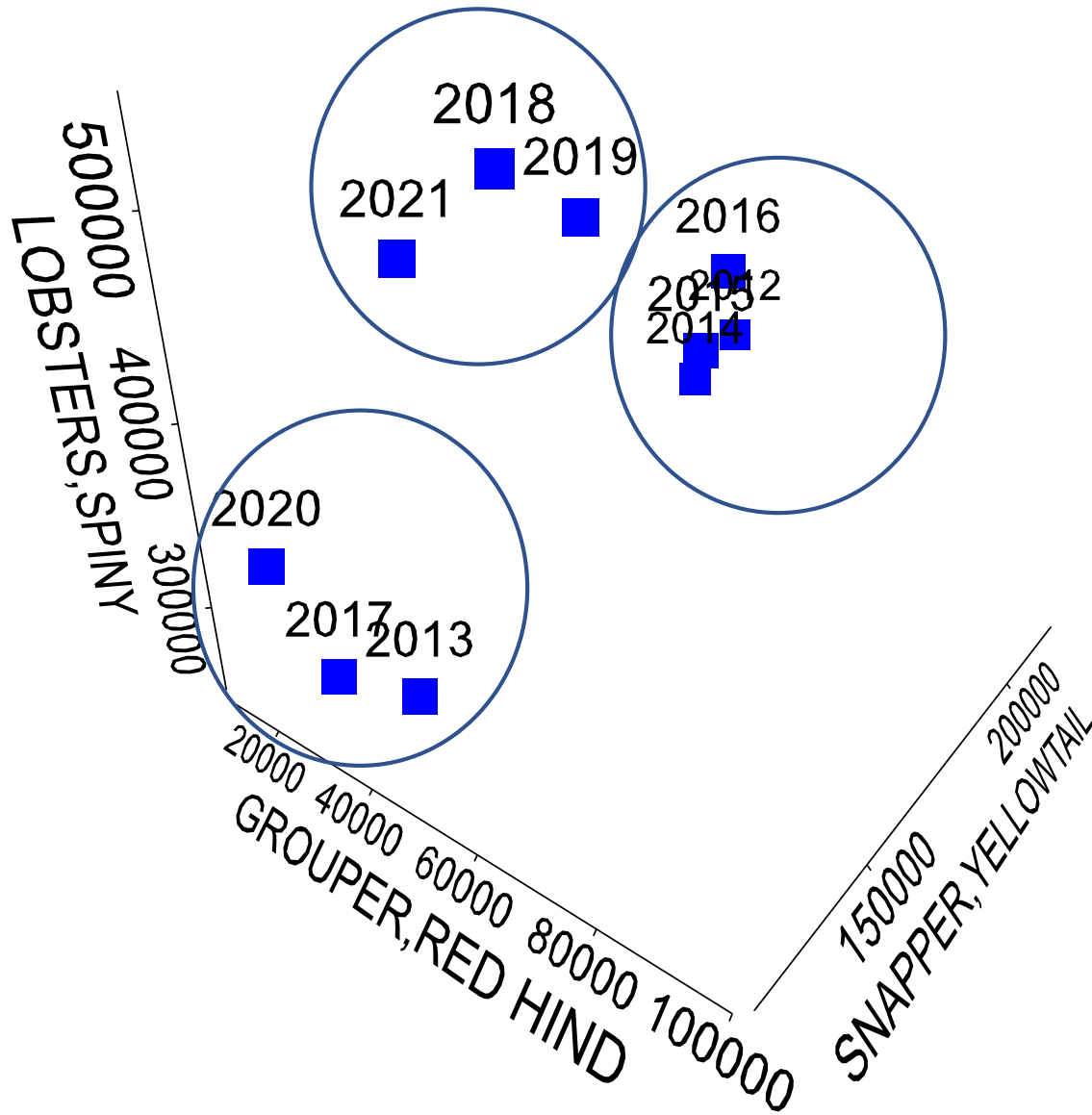
# Landings Puerto Rico



# Landings Puerto Rico

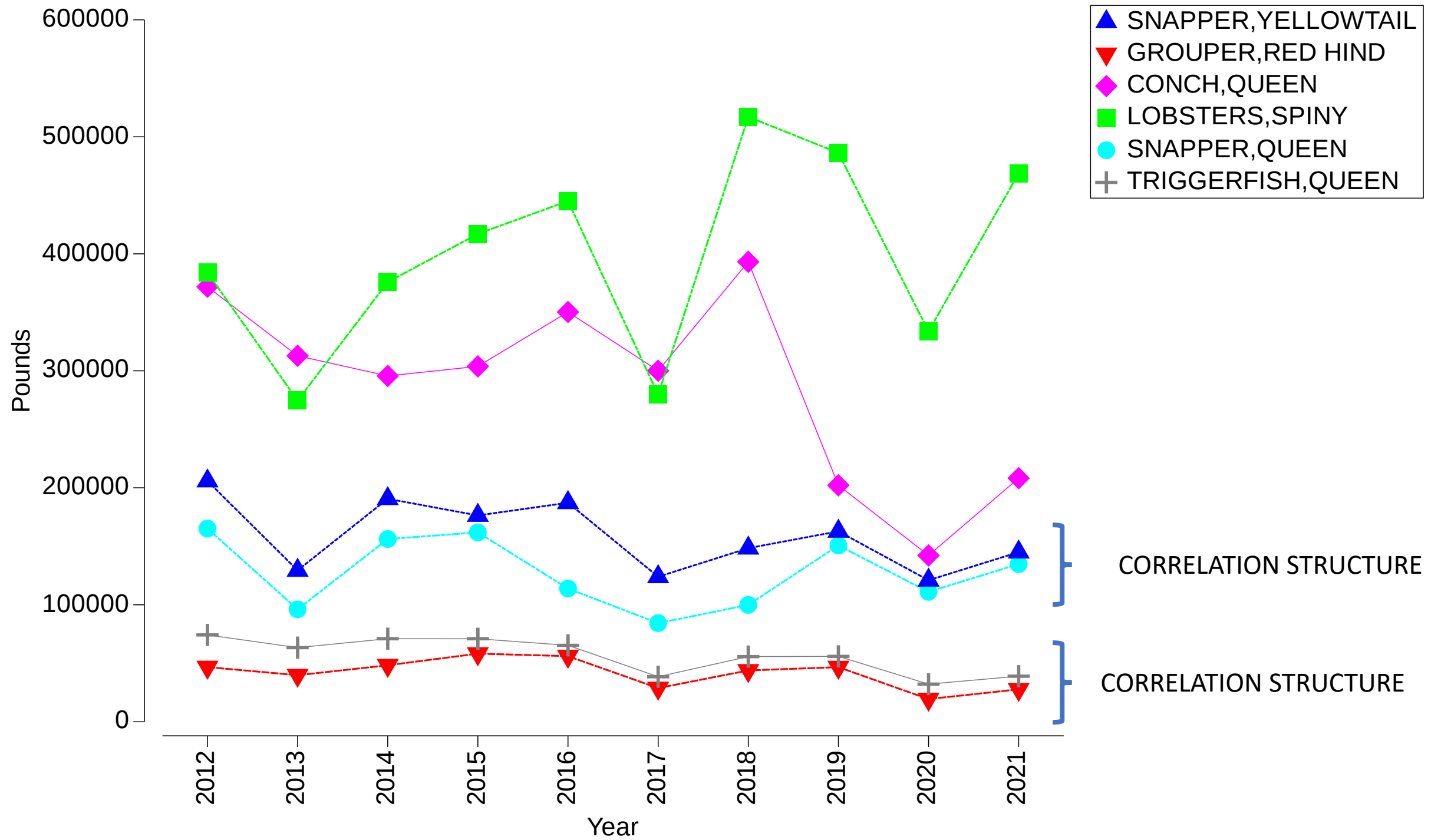


# Landings Puerto Rico

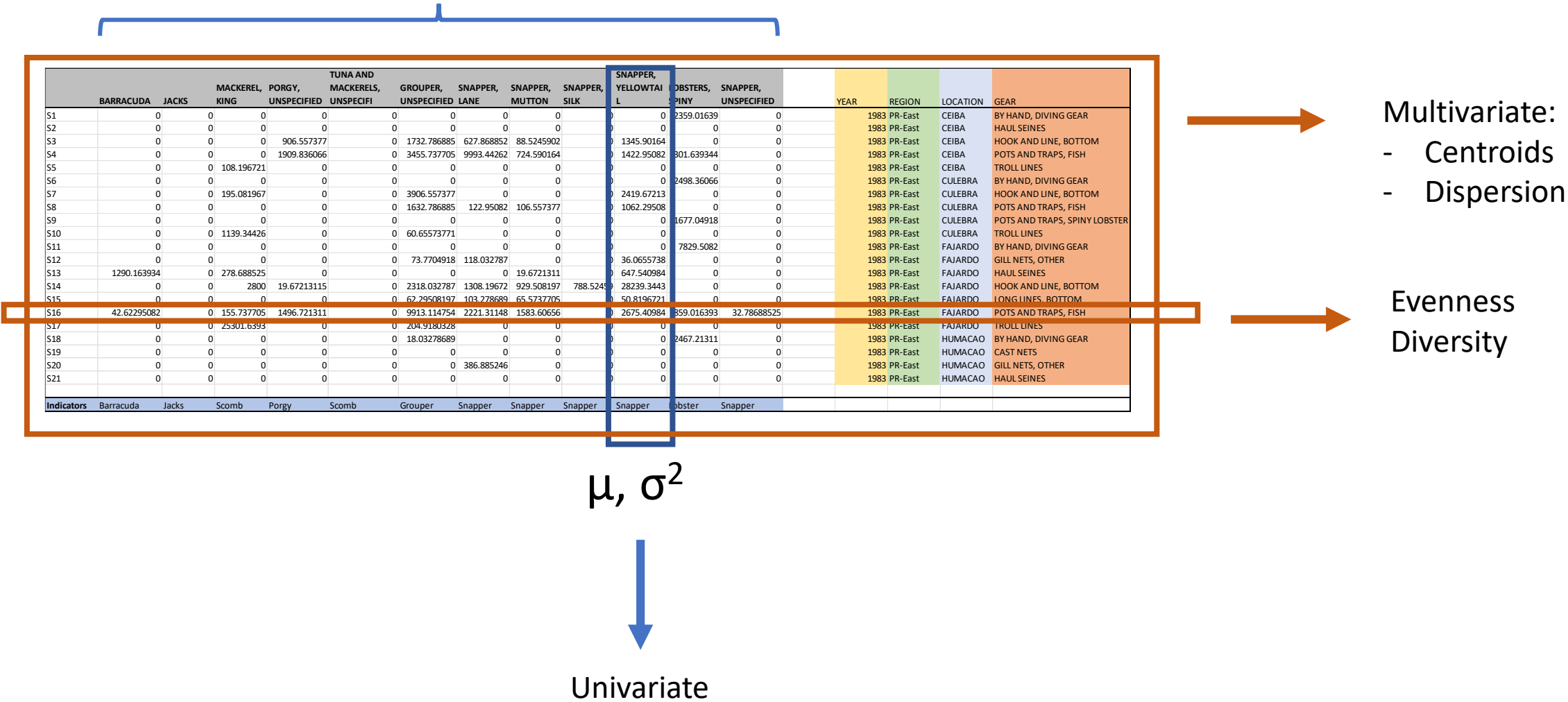


SO FAR:

- 1) Interpretation of temporal trends change as we add species (variables or dimensions)
- 2) Changes can be measured in magnitude and direction
- 3) However:
  - 1) one species left out
  - 2) Metric distances (i.e. Euclidean) not ideal for biological (alive) systems.



Corrrelation Structure



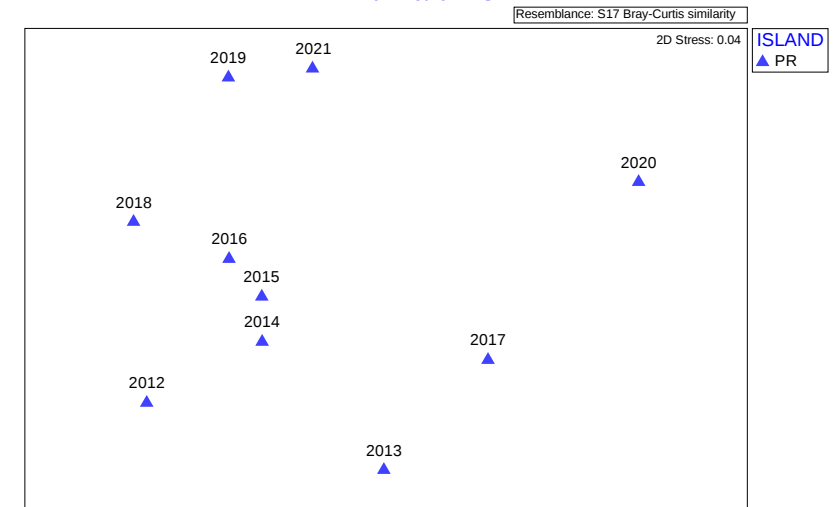
|      | Yellowtail Snapper | Red Hind    | CONCH,QUEEN | Spinny lobster | Queen Snapper | Queen Troggerfish | ..... AND 212 MORE |             |             |  |
|------|--------------------|-------------|-------------|----------------|---------------|-------------------|--------------------|-------------|-------------|--|
| 1983 | 30772.13115        | 37965.57378 | 64118.03284 | 655067.2131    | 661278.6886   | 31409.83617       | 115142.623         | 447081.9674 | 359124.5901 |  |
| 1984 | 14105.08475        | 14776.27119 | 62733.89832 | 499615.2542    | 557916.9492   | 30250.84751       | 116371.1865        | 419013.5595 | 264294.9153 |  |
| 1985 | 27250              | 11926.78571 | 59773.21429 | 464351.7857    | 489291.0714   | 32950.00003       | 71689.28571        | 374457.1429 | 228614.2857 |  |
| 1986 | 4839.999999        | 16622.66666 | 45320.00002 | 250469.3333    | 240452        | 15237.33326       | 46809.33333        | 279056      | 149984      |  |
| 1987 | 6146.666666        | 21566.66667 | 46786.66668 | 187712         | 208849.3334   | 15059.99989       | 41760.00001        | 203481.3333 | 109874.6667 |  |
| 1988 | 0                  | 13630.35714 | 78.571428   | 407889.2857    | 154675        | 11442.85718       | 44141.07143        | 250205.3572 | 135992.8572 |  |
| 1989 | 1521.568626        | 25919.60785 | 4915.686277 | 311017.6471    | 150286.2746   | 19321.56863       | 46845.09805        | 360305.8825 | 181462.7451 |  |
| 1990 | 24337.2549         | 7341.176477 | 45270.58828 | 211196.0784    | 229098.0393   | 12298.03922       | 39721.56867        | 328080.3924 | 158147.0589 |  |
| 1991 | 50947.05883        | 24064.70589 | 62964.70594 | 211001.9608    | 274013.7255   | 34260.78432       | 55892.15691        | 413200.0002 | 173105.8824 |  |
| 1992 | 27695              | 11693.33334 | 63610.00001 | 150948.3333    | 193848.3334   | 26251.66667       | 33441.66667        | 266683.3334 | 99096.66667 |  |
| 1993 | 37361.66667        | 10949.99999 | 88893.33333 | 274023.3333    | 267325        | 21430.00001       | 30543.33333        | 280486.6667 | 173771.6666 |  |
| 1994 | 41579.6875         | 16457.8125  | 81334.375   | 266390.625     | 218040.625    | 34401.5625        | 45301.5625         | 299634.375  | 146873.4375 |  |
| 1995 | 73667.60563        | 22683.09858 | 92504.22537 | 299750.7042    | 198029.5775   | 34881.69015       | 65407.04224        | 392446.4789 | 213245.0704 |  |
| 1996 | 76545.07041        | 26281.69014 | 89657.74653 | 337004.2254    | 235633.8029   | 33260.56338       | 82611.26763        | 392897.1832 | 140318.3098 |  |
| 1997 | 67957.6923         | 31655.1282  | 102502.5641 | 305108.9744    | 208311.5384   | 38735.89742       | 85755.12823        | 362697.4361 | 133603.8461 |  |
| 1998 | 57088.46152        | 40800.00001 | 114870.5128 | 333957.6923    | 142552.5641   | 27117.94872       | 61256.4103         | 380914.1027 | 135619.2308 |  |
| 1999 | 59985.89742        | 28676.92306 | 105248.718  | 272878.2051    | 149194.8718   | 32323.07691       | 57266.66671        | 417232.0513 | 160714.1025 |  |
| 2000 | 80431.57894        | 40968.42111 | 144066.667  | 490482.4562    | 199408.7722   | 40936.84211       | 98859.64947        | 448261.4041 | 212363.158  |  |
| 2001 | 86561.76473        | 24402.94118 | 109419.1176 | 356526.4706    | 222052.9412   | 33541.17647       | 97808.82349        | 410583.8236 | 139991.1765 |  |
| 2002 | 78933.72094        | 25391.86046 | 91093.02312 | 273016.279     | 170548.837    | 32361.62787       | 77912.79055        | 348845.3486 | 135287.2092 |  |
| 2003 | 62081.74358        | 17629.62665 | 101669.1905 | 344602.6305    | 183845.8104   | 32506.47723       | 66107.34992        | 395763.3344 | 141426.3759 |  |
| 2004 | 70661.74095        | 14875.61845 | 113466.1379 | 377290.2506    | 211070.3036   | 32374.42464       | 86200.00348        | 475716.8882 | 95496.82264 |  |
| 2005 | 48616.35819        | 14603.93598 | 192772.67   | 726291.148     | 294332.7272   | 18838.65476       | 127302.5546        | 772042.9109 | 259189.9256 |  |
| 2006 | 17576.14071        | 8234.421129 | 59246.56893 | 240873.3539    | 88442.54746   | 20975.45615       | 51712.67721        | 275025.8896 | 79593.14356 |  |
| 2007 | 25738.41728        | 2989.992057 | 48392.93138 | 251269.5756    | 59917.3574    | 15375.48883       | 54154.98984        | 263699.6016 | 59467.63431 |  |
| 2008 | 33101.32499        | 1953.107591 | 49757.46482 | 234501.3709    | 69209.35803   | 107356.8687       | 52284.29101        | 325832.4819 | 124282.3364 |  |
| 2009 | 45872.48167        | 2981.439648 | 57374.58386 | 271491.988     | 80044.30896   | 46550.14256       | 65100.70569        | 322016.5783 | 90587.64376 |  |
| 2010 | 30255.46703        | 1908.380255 | 55648.59918 | 269952.0684    | 51952.21384   | 49393.3923        | 54565.28943        | 288534.1282 | 76196.47805 |  |
| 2011 | 48214.37942        | 1789.410931 | 39450.71637 | 234701.8032    | 25437.54949   | 20957.35738       | 52560.41235        | 272944.9259 | 39593.64808 |  |
| 2012 | 62522.18369        | 1698.769051 | 47373.23792 | 371843.0665    | 12573.64451   | 46441.30262       | 66949.80495        | 383896.2165 | 45674.56745 |  |
| 2013 | 54039.30112        | 383.800034  | 34967.78198 | 312828.2278    | 7000.303038   | 26414.24072       | 48386.25835        | 274598.4282 | 29853.726   |  |
| 2014 | 48275.83209        | 2950.825022 | 37767.43995 | 295632.6569    | 3978.186037   | 30410.24457       | 59194.5349         | 375817.2323 | 29364.39539 |  |
| 2015 | 63521.18251        | 2144.827852 | 41337.61763 | 303764.046     | 1621.044202   | 24707.83775       | 53877.37111        | 417017.1042 | 29085.38417 |  |
| 2016 | 64229.45462        | 1406.924765 | 38274.06113 | 350256.309     | 2713.445851   | 24565.28904       | 53175.87952        | 445158.3867 | 32376.52009 |  |
| 2017 | 47537.39845        | 1384.196581 | 32406.35    | 300054.5235    | 1431.62238    | 15205.10644       | 30593.71183        | 279658.3704 | 22927.20766 |  |
| 2018 | 62816.65603        | 1382.399807 | 39054.73866 | 393161.1447    | 791.700644    | 13273.31445       | 70587.11194        | 517112.2813 | 29515.97393 |  |
| 2019 | 65196.08469        | 894.014296  | 41291.12664 | 202132.2576    | 2319.20605    | 19318.25733       | 58075.37349        | 486291.2987 | 26354.41154 |  |
| 2020 | 34452.20231        | 258.202874  | 29880.95541 | 142150.5895    | 5934.00602    | 7427.210801       | 33947.57749        | 333718.0589 | 18904.89379 |  |
| 2021 | 61233.07228        | 237.598032  | 32954.60808 | 208208.6217    | 13053.28702   | 19805.80948       | 39105.85572        | 468631.2135 | 36998.63704 |  |

|      | Yellowtail Snapper Red Hind | CONCH QUEEN | Spinny lobster | Queen Snapper | Queen Troggerfish | ....         | AND 213 MORE |
|------|-----------------------------|-------------|----------------|---------------|-------------------|--------------|--------------|
| 1983 | 8072.3335                   | 5796.5739   | 6418.0394      | 60507.2131    | 461278.6861       | 39459.83617  | 115142.621   |
| 1984 | 1405.08475                  | 14776.2719  | 62793.88832    | 40965.2542    | 557956.9402       | 30250.84751  | 116371.1865  |
| 1985 | 27250                       | 11936.78571 | 59773.21429    | 464351.7857   | 480261.0714       | 32950.00003  | 71689.28571  |
| 1986 | 4839.99999                  | 5622.66666  | 45320.00002    | 250469.3333   | 240452            | 15237.33326  | 46809.33333  |
| 1987 | 6146.66666                  | 22566.66667 | 42786.66666    | 187712        | 208491.3334       | 125039.99989 | 41780.00001  |
| 1988 | 0                           | 13630.35714 | 78.571428      | 40789.2857    | 154875            | 11442.85718  | 44141.07143  |
| 1989 | 1521.56826                  | 25918.60785 | 4915.08277     | 31107.6471    | 150286.2746       | 19321.56863  | 46845.09805  |
| 1990 | 24317.2549                  | 7345.176477 | 45270.58828    | 211196.0784   | 229080.0393       | 12298.01922  | 39721.56867  |
| 1991 | 5047.05883                  | 2484.75089  | 62964.79504    | 211001.9608   | 274613.1791       | 34262.78432  | 15903.15691  |
| 1992 | 27095                       | 11093.33334 | 63610.00001    | 105948.3333   | 193848.3334       | 26251.66667  | 33441.66667  |
| 1993 | 37361.66667                 | 30449.99999 | 88893.33333    | 274023.3333   | 267125            | 21410.00001  | 30543.33333  |
| 1994 | 41579.4875                  | 15467.8125  | 81334.375      | 26350.625     | 218493.625        | 34401.5625   | 45301.5625   |
| 1995 | 75627.65563                 | 22981.09858 | 52504.32517    | 28970.7042    | 198929.5775       | 34881.69915  | 65407.44244  |
| 1996 | 76545.07041                 | 26261.68054 | 89657.74653    | 337004.2254   | 259333.8020       | 33260.56338  | 82611.26763  |
| 1997 | 67957.6923                  | 31655.1282  | 102502.5641    | 305108.9744   | 208311.5384       | 38735.89742  | 85755.12823  |
| 1998 | 57088.46152                 | 40800.00001 | 114870.5128    | 333957.6923   | 142552.5541       | 27117.94872  | 61256.4103   |
| 1999 | 59985.80742                 | 28675.62336 | 182340.718     | 273838.2051   | 149194.8718       | 52310.07091  | 57386.66671  |
| 2000 | 80431.57894                 | 40048.42111 | 144006.667     | 400482.4562   | 199408.7722       | 40936.84211  | 98859.64947  |
| 2001 | 86561.76473                 | 24402.94138 | 109419.1176    | 356526.9432   | 222052.9412       | 33541.17647  | 97808.62349  |
| 2002 | 79913.72094                 | 21391.86046 | 92093.62112    | 279264.279    | 170548.837        | 32361.62787  | 77913.76005  |
| 2003 | 61361.74358                 | 17620.62485 | 101669.1905    | 344602.6395   | 183845.8034       | 32506.47733  | 66107.34902  |
| 2004 | 70661.74095                 | 14875.63485 | 113466.1379    | 377290.2506   | 213070.3036       | 32374.42464  | 86200.00348  |
| 2005 | 48616.35819                 | 14603.93938 | 192772.67      | 762091.148    | 294332.7272       | 18838.65476  | 127802.5546  |
| 2006 | 17576.14071                 | 8234.421129 | 58346.58893    | 240873.9339   | 88442.14746       | 20975.45815  | 51712.07721  |
| 2007 | 25738.41738                 | 2895.89257  | 45001.89138    | 252388.9736   | 29917.3274        | 15375.48889  | 54154.88884  |
| 2008 | 33101.33499                 | 19573.50581 | 48757.46482    | 234501.3700   | 69038.35803       | 107356.8687  | 52384.29101  |
| 2009 | 41872.48167                 | 2981.439548 | 57374.58386    | 271491.988    | 80044.30896       | 46550.14256  | 65100.70569  |
| 2010 | 30255.46701                 | 1938.380255 | 55648.59918    | 269952.0884   | 51952.21384       | 49193.3023   | 54565.28943  |
| 2011 | 40314.17943                 | 1789.410891 | 39602.71837    | 234745.4892   | 25491.54849       | 20951.31386  | 12560.41391  |
| 2012 | 6522.18369                  | 3688.780651 | 47373.23792    | 371843.0665   | 12573.64651       | 46441.30262  | 66949.80495  |
| 2013 | 14039.30112                 | 3811.800394 | 34967.78198    | 312828.2278   | 7000.303038       | 26414.24072  | 48386.25835  |
| 2014 | 44875.83209                 | 2950.829202 | 37767.43995    | 205102.6589   | 3978.188037       | 30410.24457  | 59194.5349   |
| 2015 | 65212.18251                 | 2144.827862 | 42357.63763    | 307354.046    | 1621.040302       | 24703.83776  | 53877.71111  |
| 2016 | 64209.45462                 | 14026.04765 | 38274.06113    | 35056.309     | 2713.458851       | 24565.28904  | 53175.87962  |
| 2017 | 47537.38845                 | 1384.195881 | 32406.35       | 300054.5285   | 1431.62238        | 15205.10644  | 30593.71183  |
| 2018 | 62816.65903                 | 1382.399807 | 39054.73866    | 303161.1447   | 791.700644        | 13273.31445  | 70587.11194  |
| 2019 | 65196.08469                 | 894.040296  | 42261.2654     | 302112.2576   | 2133.30605        | 19318.37518  | 14075.17349  |
| 2020 | 34452.30311                 | 258.208204  | 29880.95141    | 142150.5895   | 5934.00602        | 7427.210801  | 33947.57749  |
| 2021 | 61333.07228                 | 237.588032  | 32954.60808    | 208208.6217   | 13053.28702       | 19805.80948  | 39105.85572  |

Dis/Similarity index (e.g. Bray-Curtis)  
Non metric, No assumptions (e.g. lineal)  
Data as it is, Simple

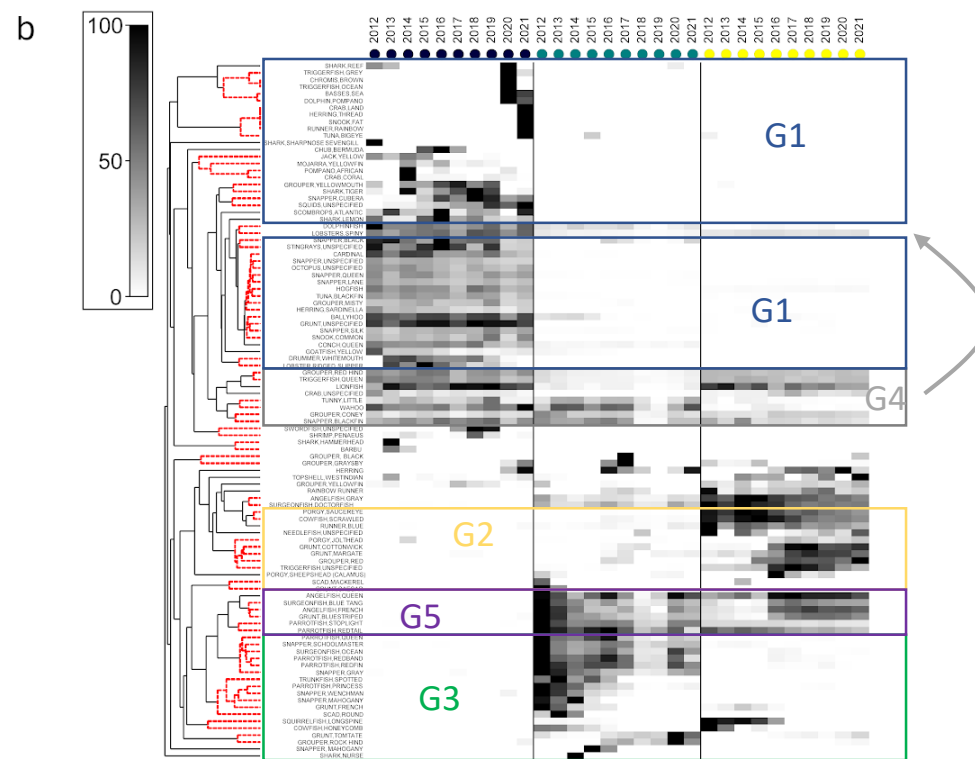
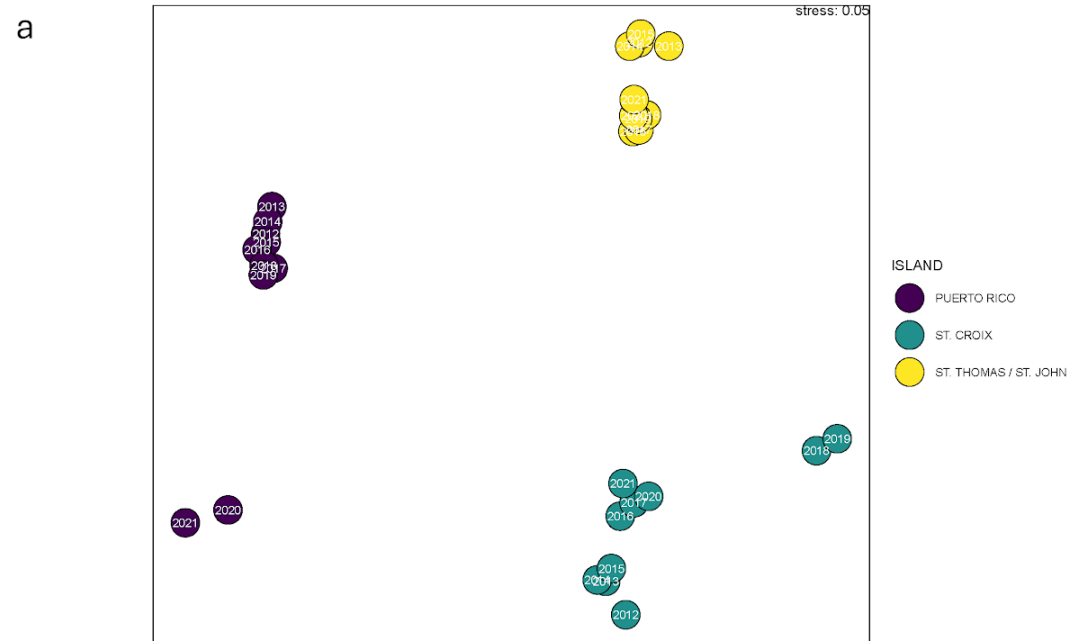
|      | 1983 | 1984 | .... | 2020 | 2021 |
|------|------|------|------|------|------|
| 1983 |      |      |      |      |      |
| 1984 | 92   |      |      |      |      |
| ...  | 89   | 94   |      |      |      |
| ...  | 64   | 70   | 72   |      |      |
| ...  | 51   | 57   | 59   | 84   |      |
| ...  | 58   | 64   | 66   | 80   | 80   |
| 2020 | 67   | 73   | 75   | 83   | 71   |
| 2021 | 62   | 68   | 70   | 81   | 77   |

## Ordinations

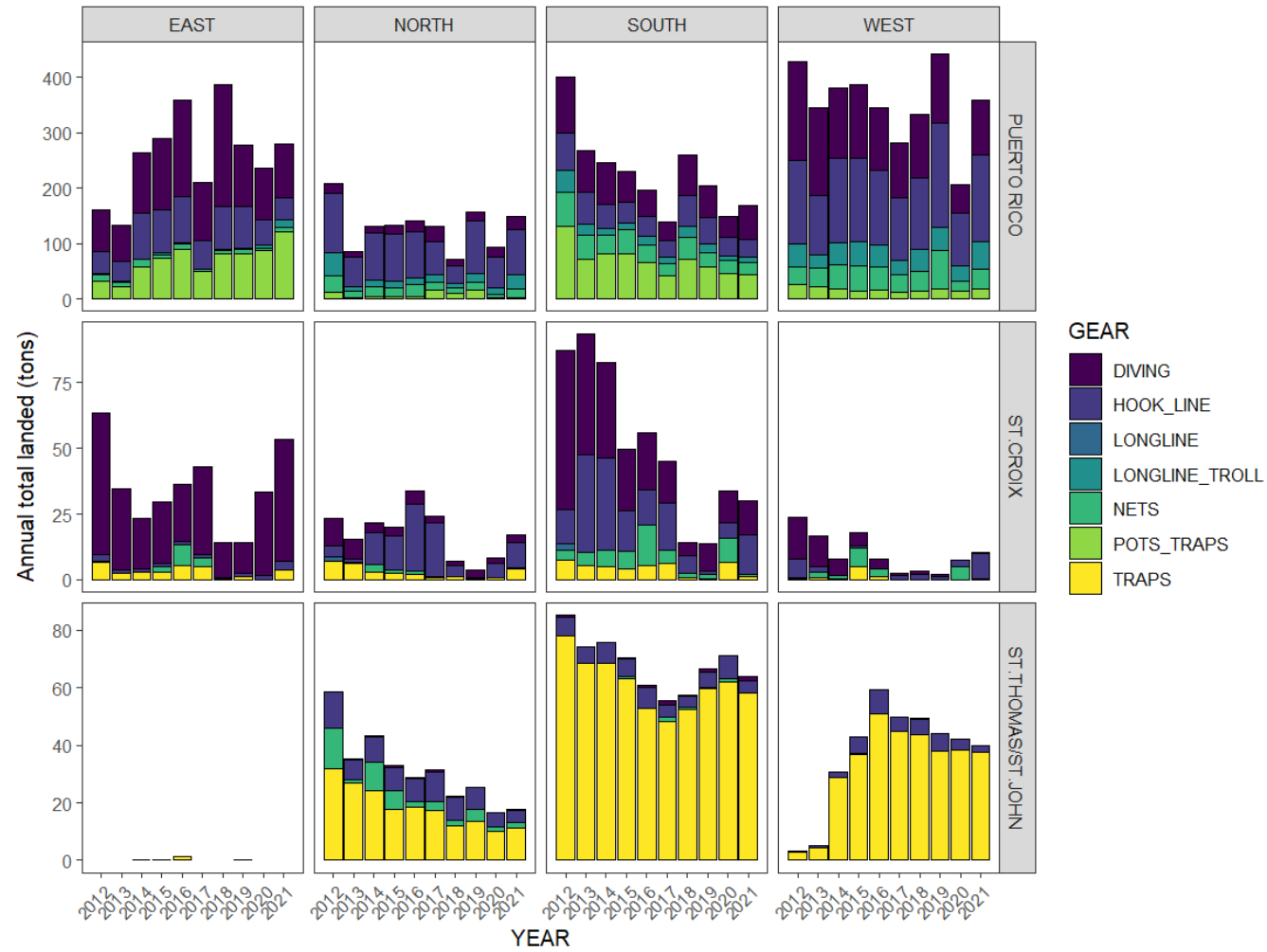


- Formal statistics:
  - Non-parametric,
  - No assumptions
  - More power

- Multiple correlations:
  - Environmental,
  - Fisheries independent
  - Habitat
  - Socio-economic



## Relative Landings per gear/region/year



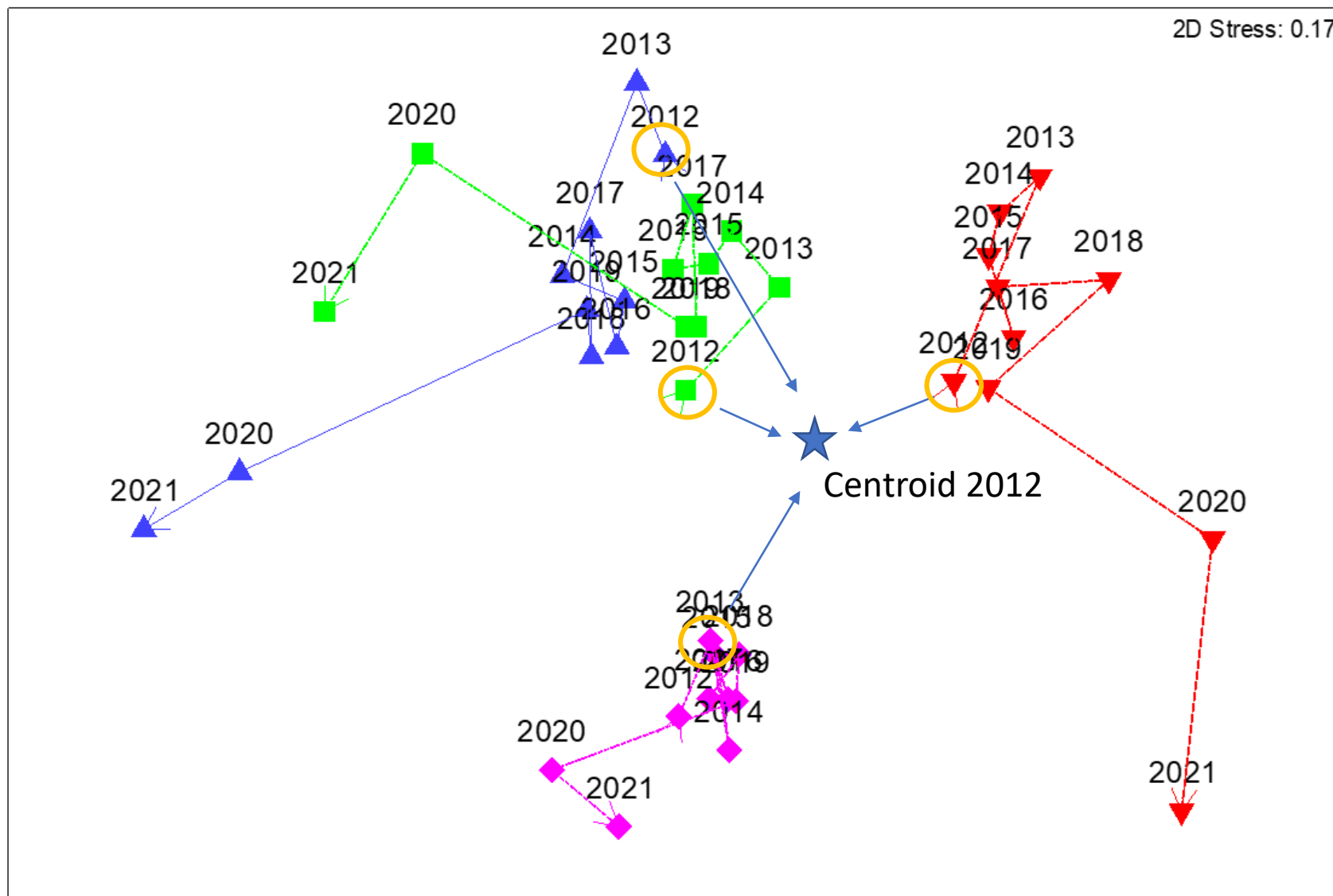
## Puerto Rico Landings

Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.17

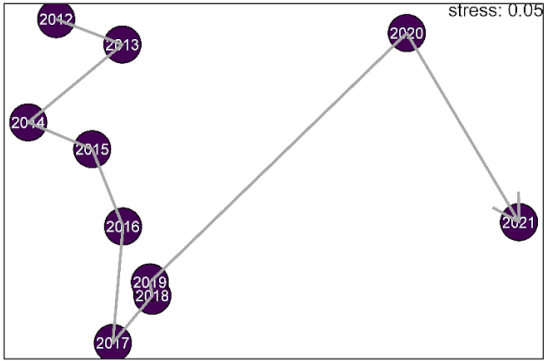
### FISHING\_ZONE

- EAST
- NORTH
- SOUTH
- WEST



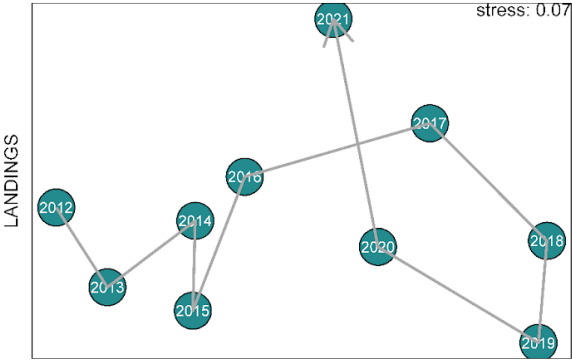
PUERTO RICO

ordered ANOSIM test:  $R = 0.74$ ;  $p\text{-value} < 0.001$



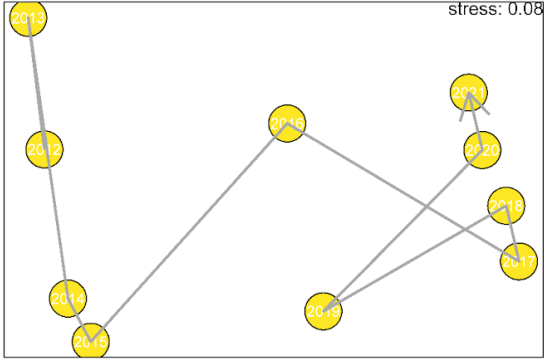
ST. CROIX

ordered ANOSIM test:  $R = 0.49$ ;  $p\text{-value} < 0.001$



ST. THOMAS/ST. JOHN

ordered ANOSIM test:  $R = 0.38$ ;  $p\text{-value} < 0.001$

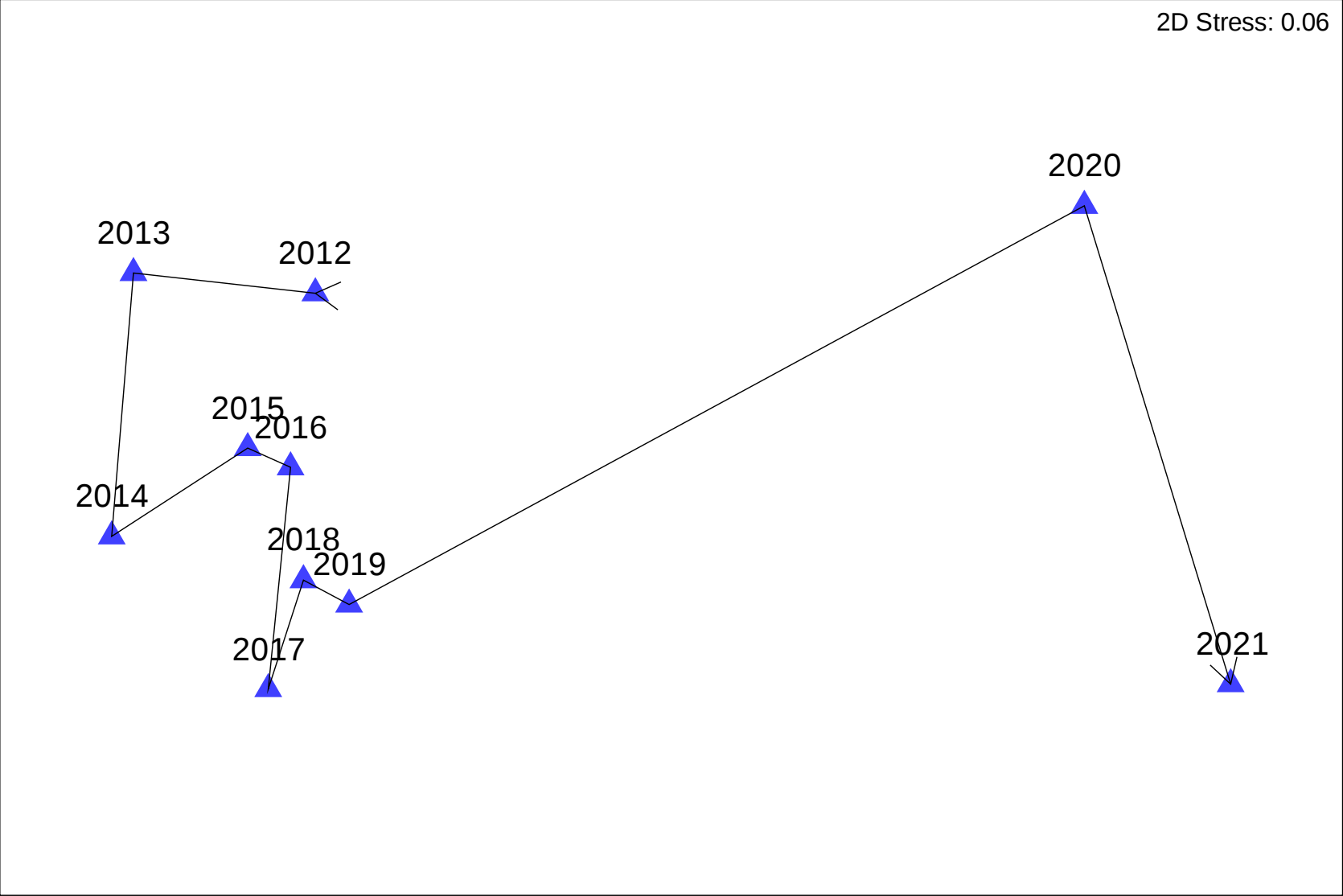


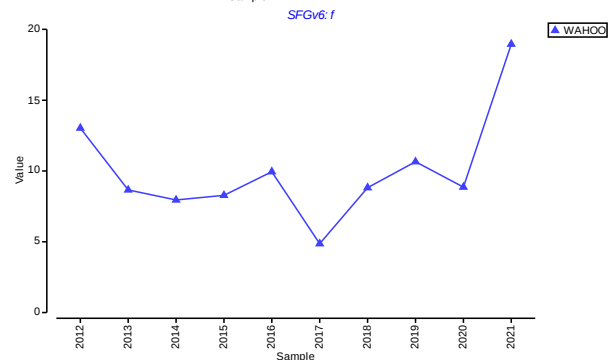
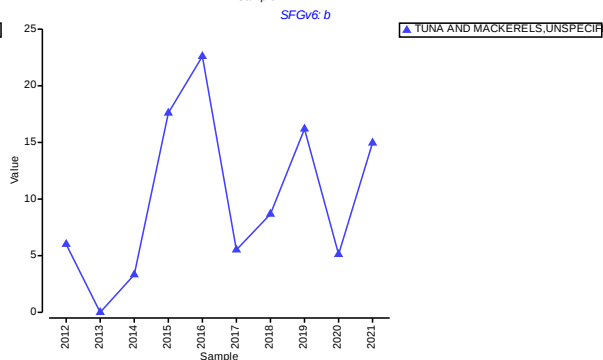
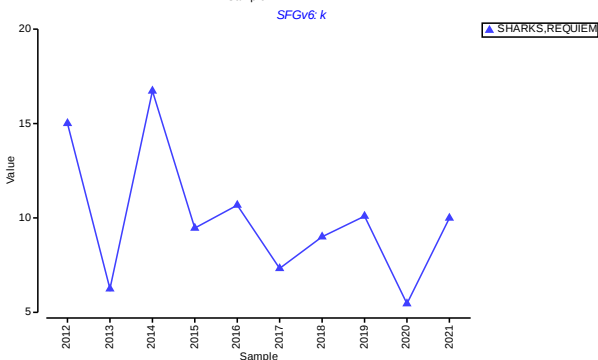
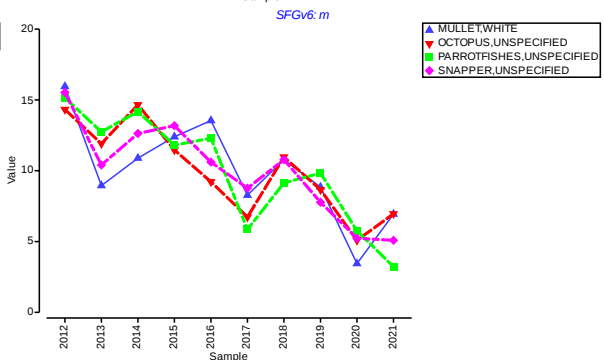
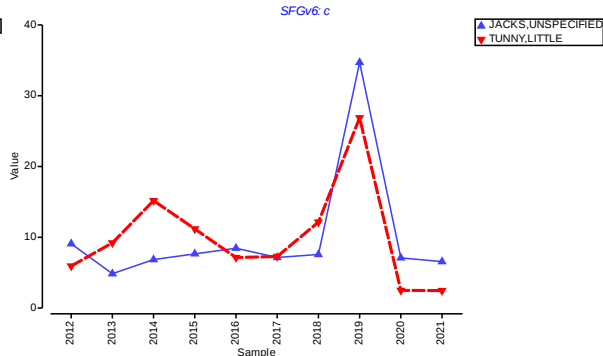
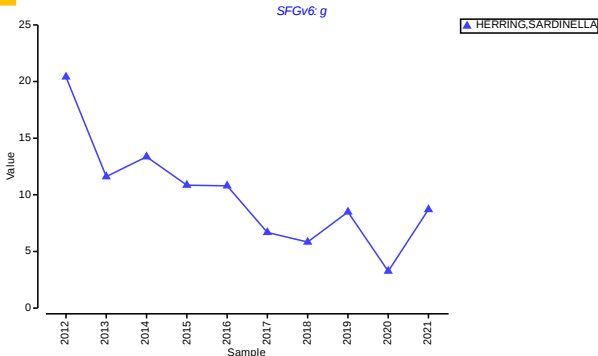
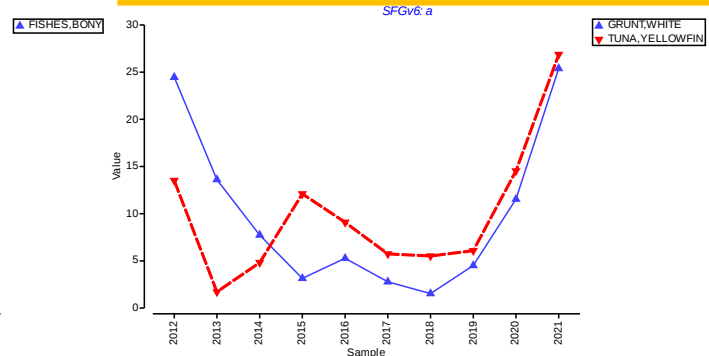
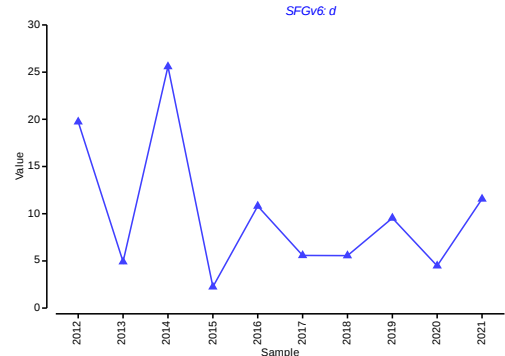
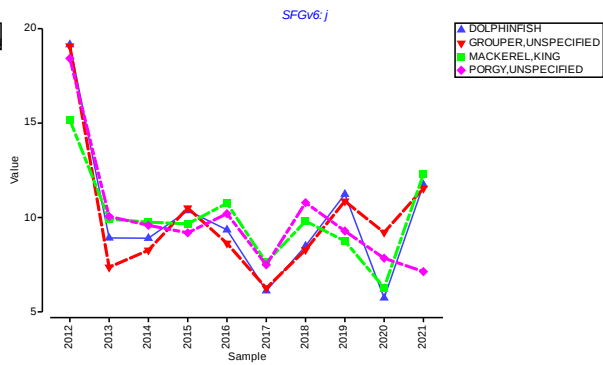
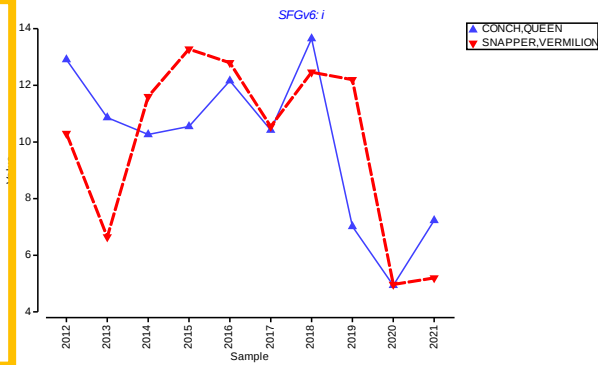
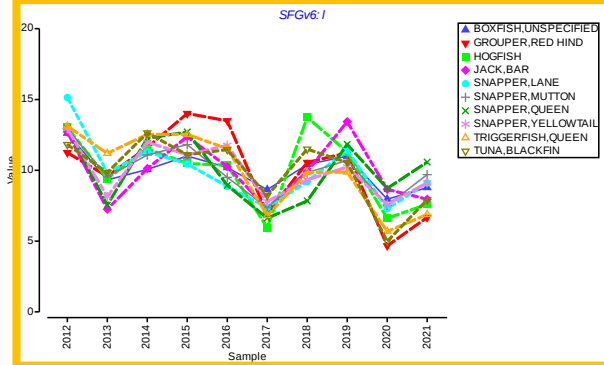
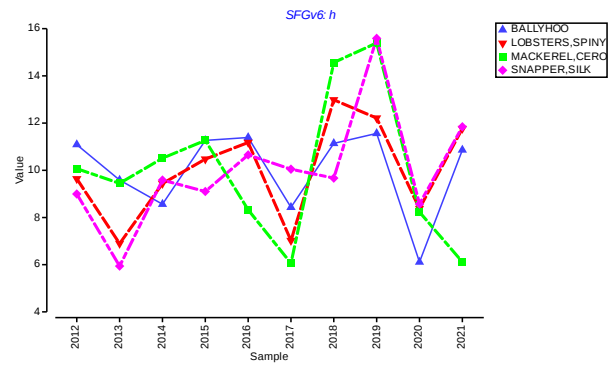
Centroids Puerto Rico Landings  
Non-metric MDS

Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

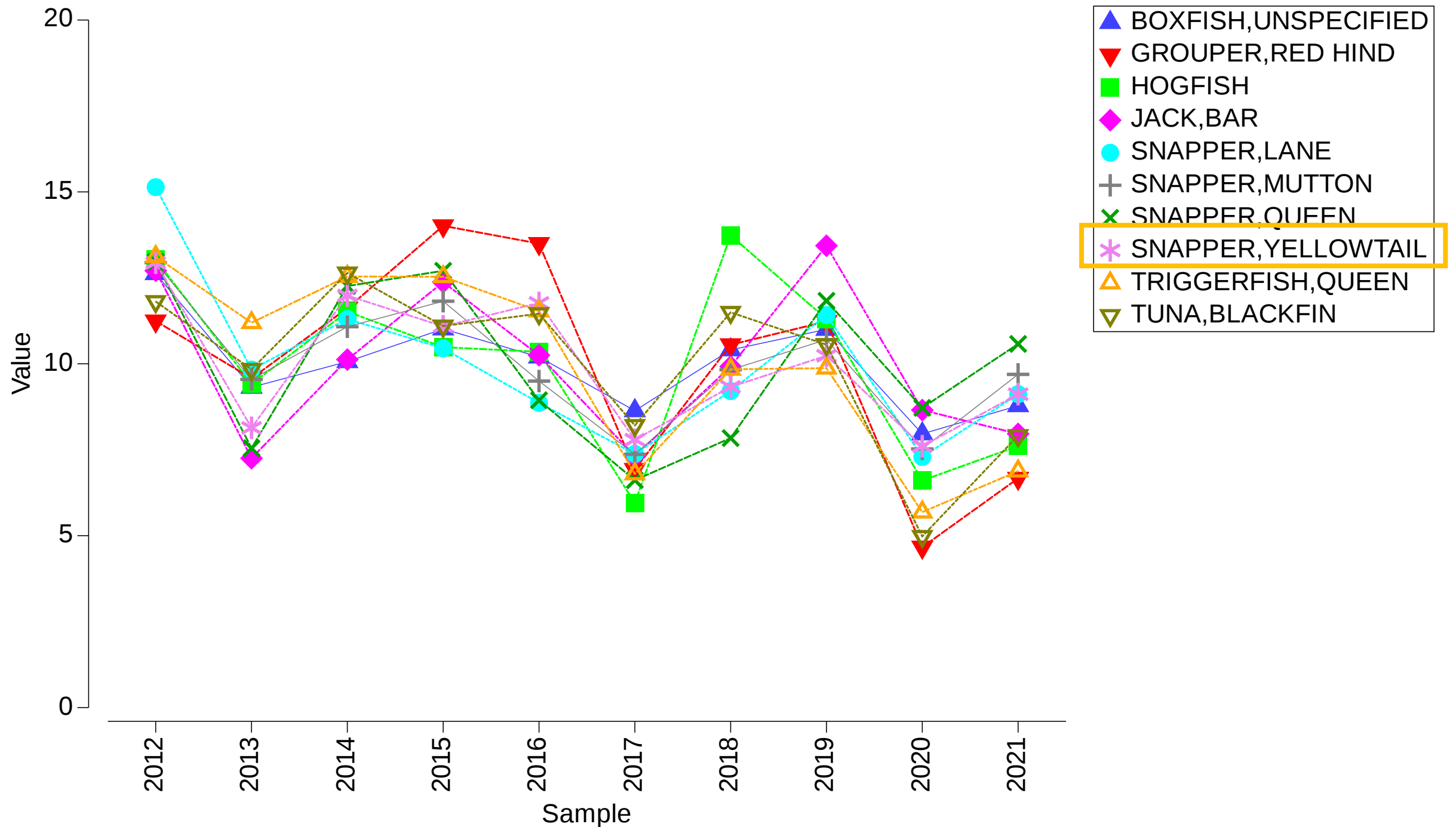
2D Stress: 0.06

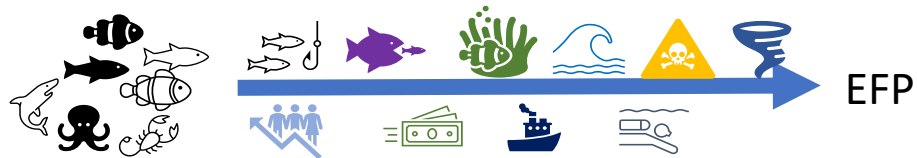
ISLAND  
▲ PR





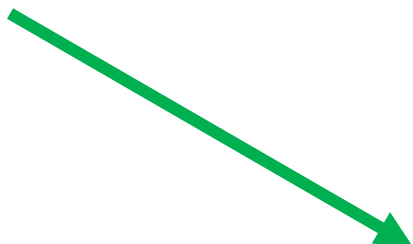
*SFGv6: I*





SO FAR....USING a multi-species approach:

- 1) Patterns of spatial and temporal variation of the landings (or any other matrix....TIP, Fisjh. Ind) can be described using the entire suite of species/groups.
- 2) Species responsible for those patterns can be described
- 3) Correlations structure can be identified among those species/groups
- 4) Changes can be measured in magnitude and direction



**BUT.....what is a “good/bad” or a (un)desirable “Change”**

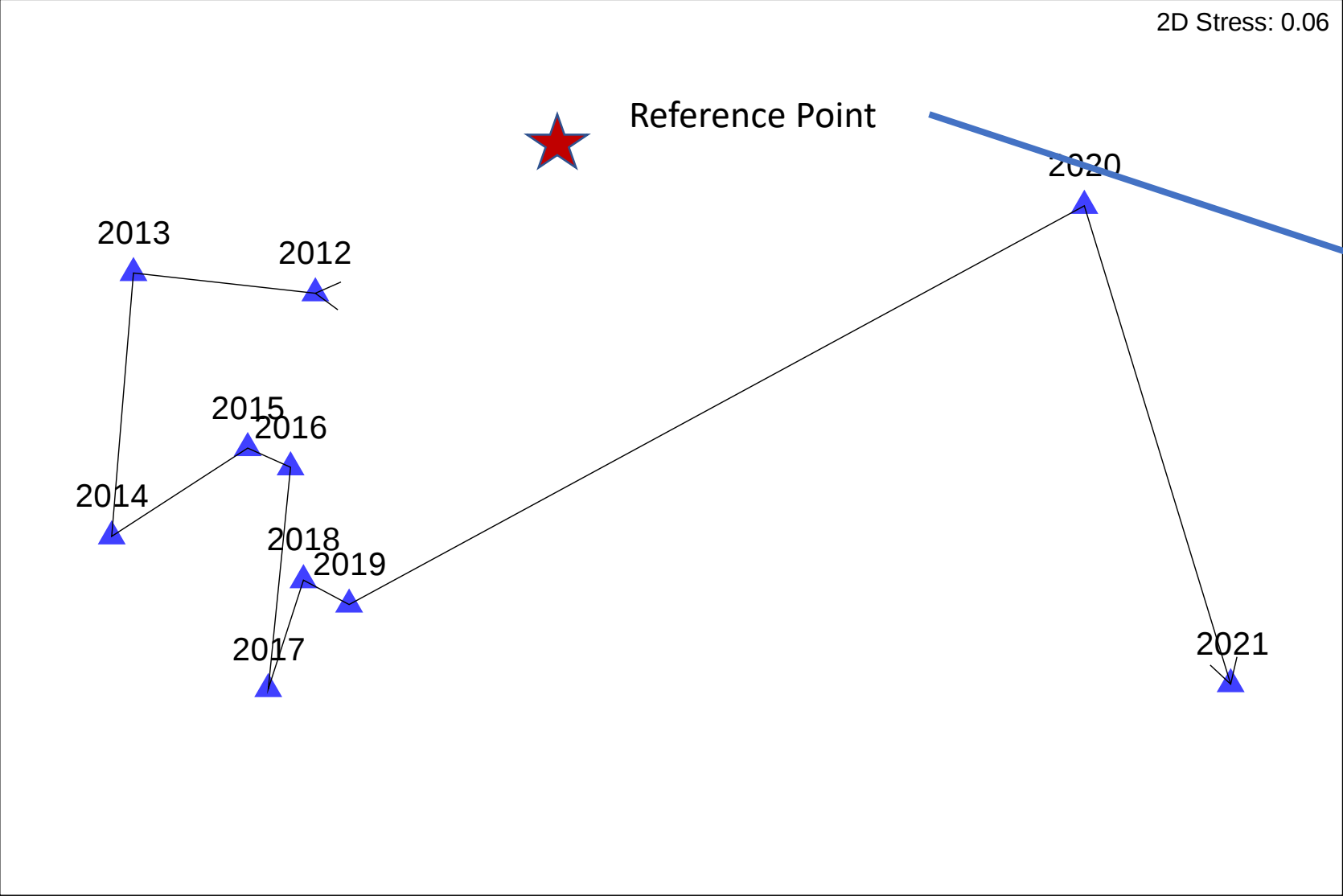
# Centroids Puerto Rico Landings

## Non-metric MDS

Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.06

ISLAND  
▲ PR



HOW?

- 1) Increase cost-benefit?
- 2) Increase diversity?
- 3) Increase Biomass?
- 4) Increase value?
- 5) Existing Management options?



Stakeholder engagement

|      | Yellowtail Snapper | Red Hind    | CONCH,QUEEN | Spinny lobster | Queen Snapper | Queen Troggerfish | ..... AND 212 MORE |             |             |
|------|--------------------|-------------|-------------|----------------|---------------|-------------------|--------------------|-------------|-------------|
| 1983 | 30772.13115        | 37965.57378 | 64118.03284 | 655067.2131    | 661278.6886   | 31409.83617       | 115142.623         | 447081.9674 | 359124.5901 |
| 1984 | 14105.08475        | 14776.27119 | 62733.89832 | 499615.2542    | 557916.9492   | 30250.84751       | 116371.1865        | 419013.5595 | 264294.9153 |
| 1985 | 27250              | 11926.78571 | 59773.21429 | 464351.7857    | 489291.0714   | 32950.00003       | 71689.28571        | 374457.1429 | 228614.2857 |
| 1986 | 4839.999999        | 16622.66666 | 45320.00002 | 250469.3333    | 240452        | 15237.33326       | 46809.33333        | 279056      | 149984      |
| 1987 | 6146.666666        | 21566.66667 | 46786.66668 | 187712         | 208849.3334   | 15059.99989       | 41760.00001        | 203481.3333 | 109874.6667 |
| 1988 | 0                  | 13630.35714 | 78.571428   | 407889.2857    | 154675        | 11442.85718       | 44141.07143        | 250205.3572 | 135992.8572 |
| 1989 | 1521.568626        | 25919.60785 | 4915.686277 | 311017.6471    | 150286.2746   | 19321.56863       | 46845.09805        | 360305.8825 | 181462.7451 |
| 1990 | 24337.2549         | 7341.176477 | 45270.58828 | 211196.0784    | 229098.0393   | 12298.03922       | 39721.56867        | 328080.3924 | 158147.0589 |
| 1991 | 50947.05883        | 24064.70589 | 62964.70594 | 211001.9608    | 274013.7255   | 34260.78432       | 55892.15691        | 413200.0002 | 173105.8824 |
| 1992 | 27695              | 11693.33334 | 63610.00001 | 150948.3333    | 193848.3334   | 26251.66667       | 33441.66667        | 266683.3334 | 99096.66667 |
| 1993 | 37361.66667        | 10949.99999 | 88893.33333 | 274023.3333    | 267325        | 21430.00001       | 30543.33333        | 280486.6667 | 173771.6666 |
| 1994 | 41579.6875         | 16457.8125  | 81334.375   | 266390.625     | 218040.625    | 34401.5625        | 45301.5625         | 299634.375  | 146873.4375 |
| 1995 | 73667.60563        | 22683.09858 | 92504.22537 | 299750.7042    | 198029.5775   | 34881.69015       | 65407.04224        | 392446.4789 | 213245.0704 |
| 1996 | 76545.07041        | 26281.69014 | 89657.74653 | 337004.2254    | 235633.8029   | 33260.56338       | 82611.26763        | 392897.1832 | 140318.3098 |
| 1997 | 67957.6923         | 31655.1282  | 102502.5641 | 305108.9744    | 208311.5384   | 38735.89742       | 85755.12823        | 362697.4361 | 133603.8461 |
| 1998 | 57088.46152        | 40800.00001 | 114870.5128 | 333957.6923    | 142552.5641   | 27117.94872       | 61256.4103         | 380914.1027 | 135619.2308 |
| 1999 | 59985.89742        | 28676.92306 | 105248.718  | 272878.2051    | 149194.8718   | 32323.07691       | 57266.66671        | 417232.0513 | 160714.1025 |
| 2000 | 80431.57894        | 40968.42111 | 144066.667  | 490482.4562    | 199408.7722   | 40936.84211       | 98859.64947        | 448261.4041 | 212363.158  |
| 2001 | 86561.76473        | 24402.94118 | 109419.1176 | 356526.4706    | 222052.9412   | 33541.17647       | 97808.82349        | 410583.8236 | 139991.1765 |
| 2002 | 78933.72094        | 25391.86046 | 91093.02312 | 273016.279     | 170548.837    | 32361.62787       | 77912.79055        | 348845.3486 | 135287.2092 |
| 2003 | 62081.74358        | 17629.62665 | 101669.1905 | 344602.6305    | 183845.8104   | 32506.47723       | 66107.34992        | 395763.3344 | 141426.3759 |
| 2004 | 70661.74095        | 14875.61845 | 113466.1379 | 377290.2506    | 211070.3036   | 32374.42464       | 86200.00348        | 475716.8882 | 95496.82264 |
| 2005 | 48616.35819        | 14603.93598 | 192772.67   | 726291.148     | 294332.7272   | 18838.65476       | 127302.5546        | 772042.9109 | 259189.9256 |
| 2006 | 17576.14071        | 8234.421129 | 59246.56893 | 240873.3539    | 88442.54746   | 20975.45615       | 51712.67721        | 275025.8896 | 79593.14356 |
| 2007 | 25738.41728        | 2989.992057 | 48392.93138 | 251269.5756    | 59917.3574    | 15375.48883       | 54154.98984        | 263699.6016 | 59467.63431 |
| 2008 | 33101.32499        | 1953.107591 | 49757.46482 | 234501.3709    | 69209.35803   | 107356.8687       | 52284.29101        | 325832.4819 | 124282.3364 |
| 2009 | 45872.48167        | 2981.439648 | 57374.58386 | 271491.988     | 80044.30896   | 46550.14256       | 65100.70569        | 322016.5783 | 90587.64376 |
| 2010 | 30255.46703        | 1908.380255 | 55648.59918 | 269952.0684    | 51952.21384   | 49393.3923        | 54565.28943        | 288534.1282 | 76196.47805 |
| 2011 | 48214.37942        | 1789.410931 | 39450.71637 | 234701.8032    | 25437.54949   | 20957.35738       | 52560.41235        | 272944.9259 | 39593.64808 |
| 2012 | 62522.18369        | 1698.769051 | 47373.23792 | 371843.0665    | 12573.64451   | 46441.30262       | 66949.80495        | 383896.2165 | 45674.56745 |
| 2013 | 54039.30112        | 383.800034  | 34967.78198 | 312828.2278    | 7000.303038   | 26414.24072       | 48386.25835        | 274598.4282 | 29853.726   |
| 2014 | 48275.83209        | 2950.825022 | 37767.43995 | 295632.6569    | 3978.186037   | 30410.24457       | 59194.5349         | 375817.2323 | 29364.39539 |
| 2015 | 63521.18251        | 2144.827852 | 41337.61763 | 303764.046     | 1621.044202   | 24707.83775       | 53877.37111        | 417017.1042 | 29085.38417 |
| 2016 | 64229.45462        | 1406.924765 | 38274.06113 | 350256.309     | 2713.445851   | 24565.28904       | 53175.87952        | 445158.3867 | 32376.52009 |
| 2017 | 47537.39845        | 1384.196581 | 32406.35    | 300054.5235    | 1431.62238    | 15205.10644       | 30593.71183        | 279658.3704 | 22927.20766 |
| 2018 | 62816.65603        | 1382.399807 | 39054.73866 | 393161.1447    | 791.700644    | 13273.31445       | 70587.11194        | 517112.2813 | 29515.97393 |
| 2019 | 65196.08469        | 894.014296  | 41291.12664 | 202132.2576    | 2319.20605    | 19318.25733       | 58075.37349        | 486291.2987 | 26354.41154 |
| 2020 | 34452.20231        | 258.202874  | 29880.95541 | 142150.5895    | 5934.00602    | 7427.210801       | 33947.57749        | 333718.0589 | 18904.89379 |
| 2021 | 61233.07228        | 237.598032  | 32954.60808 | 208208.6217    | 13053.28702   | 19805.80948       | 39105.85572        | 468631.2135 | 36998.63704 |

|     |        |       |       |       |        |        |        |       |       |
|-----|--------|-------|-------|-------|--------|--------|--------|-------|-------|
| ACL | 700000 | 80000 | 80000 | 50000 | 330000 | 233000 | 550000 | 75000 | 82000 |
|-----|--------|-------|-------|-------|--------|--------|--------|-------|-------|

# *Puerto Rico Landings*

## *Non-metric MDS*

Standardise Samples by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.03

ISLAND

▲ PR  
◆ Puerto Rico FMP

2013 2012  
2017 2014  
2015  
2016  
2018  
2019  
2020  
2021

ACL



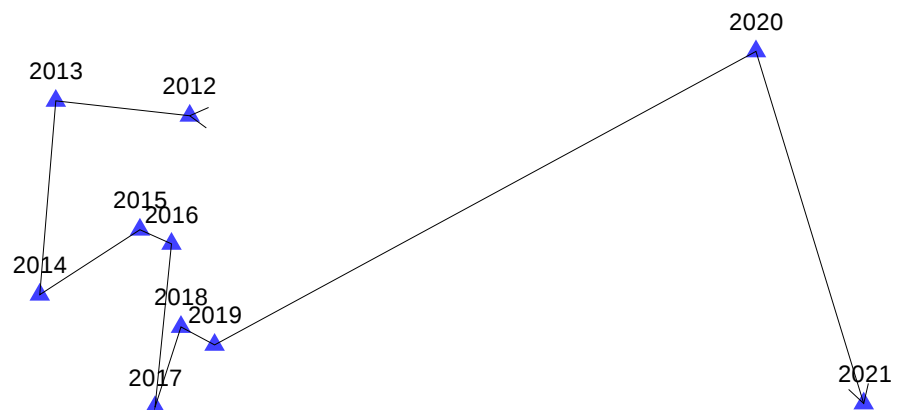
### Centroids Puerto Rico Landings Non-metric MDS

Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.06

ISLAND

▲ PR



### Puerto Rico Landings Non-metric MDS

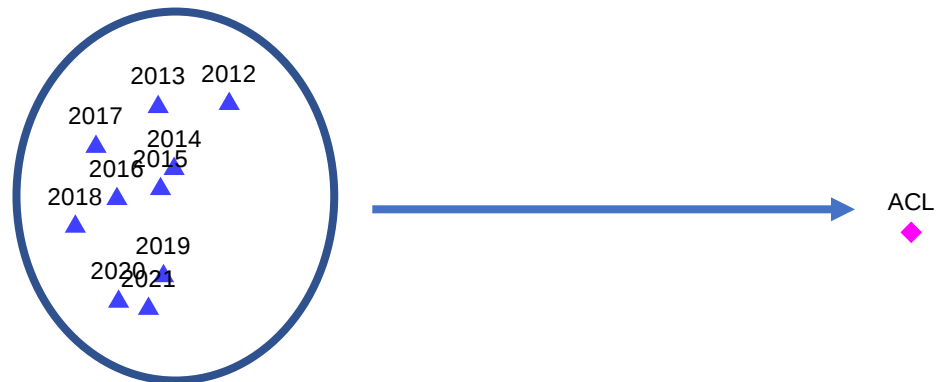
Standardise Samples by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.03

ISLAND

▲ PR

◆ Puerto Rico FMP

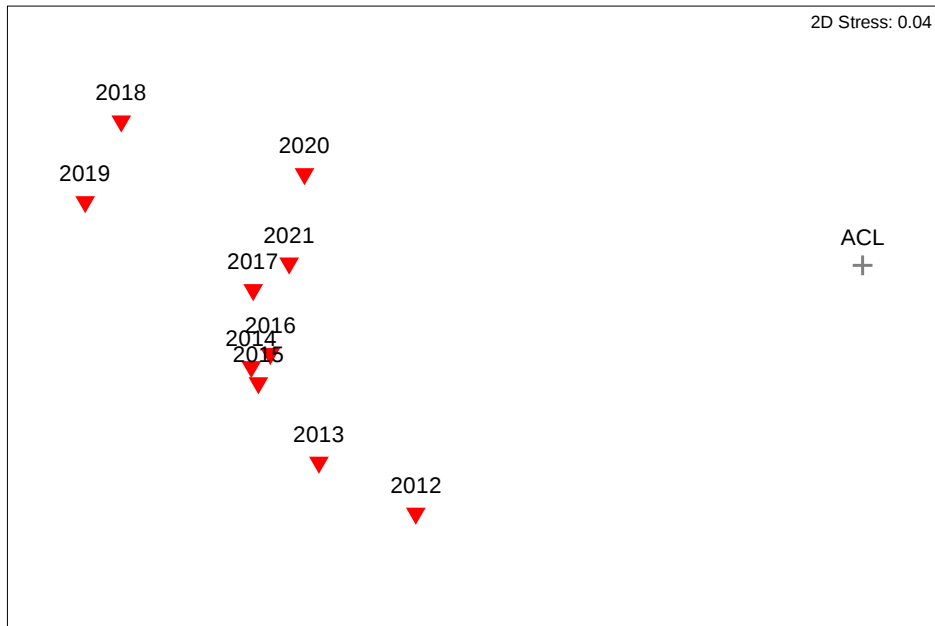


*Landings St. Croix*  
*Non-metric MDS*

Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.04

ISLAND  
▼ STC  
+ St. Croix FMP

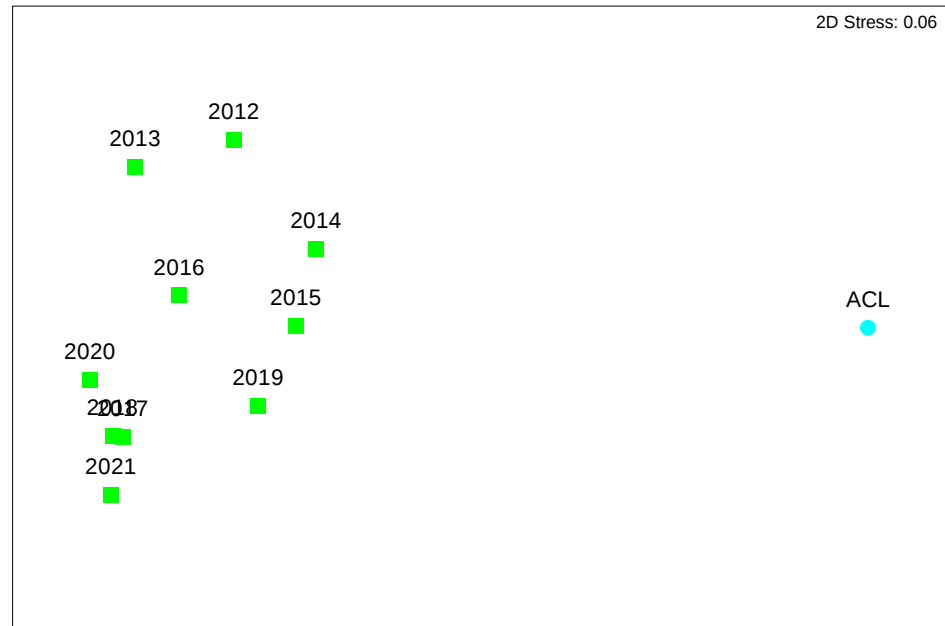


*Landings St. Thomas/St. John*  
*Non-metric MDS*

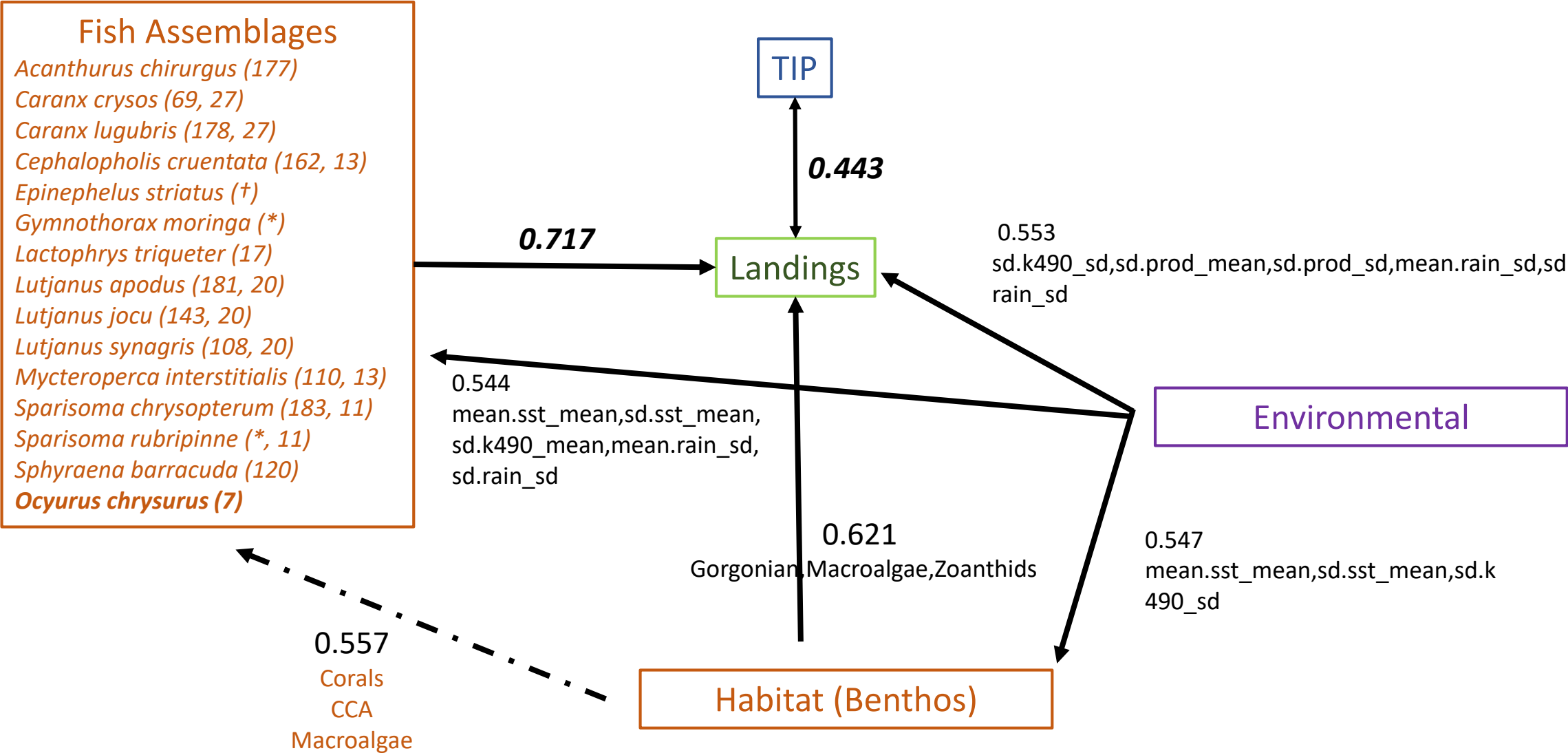
Standardise Variables by Maximum  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.06

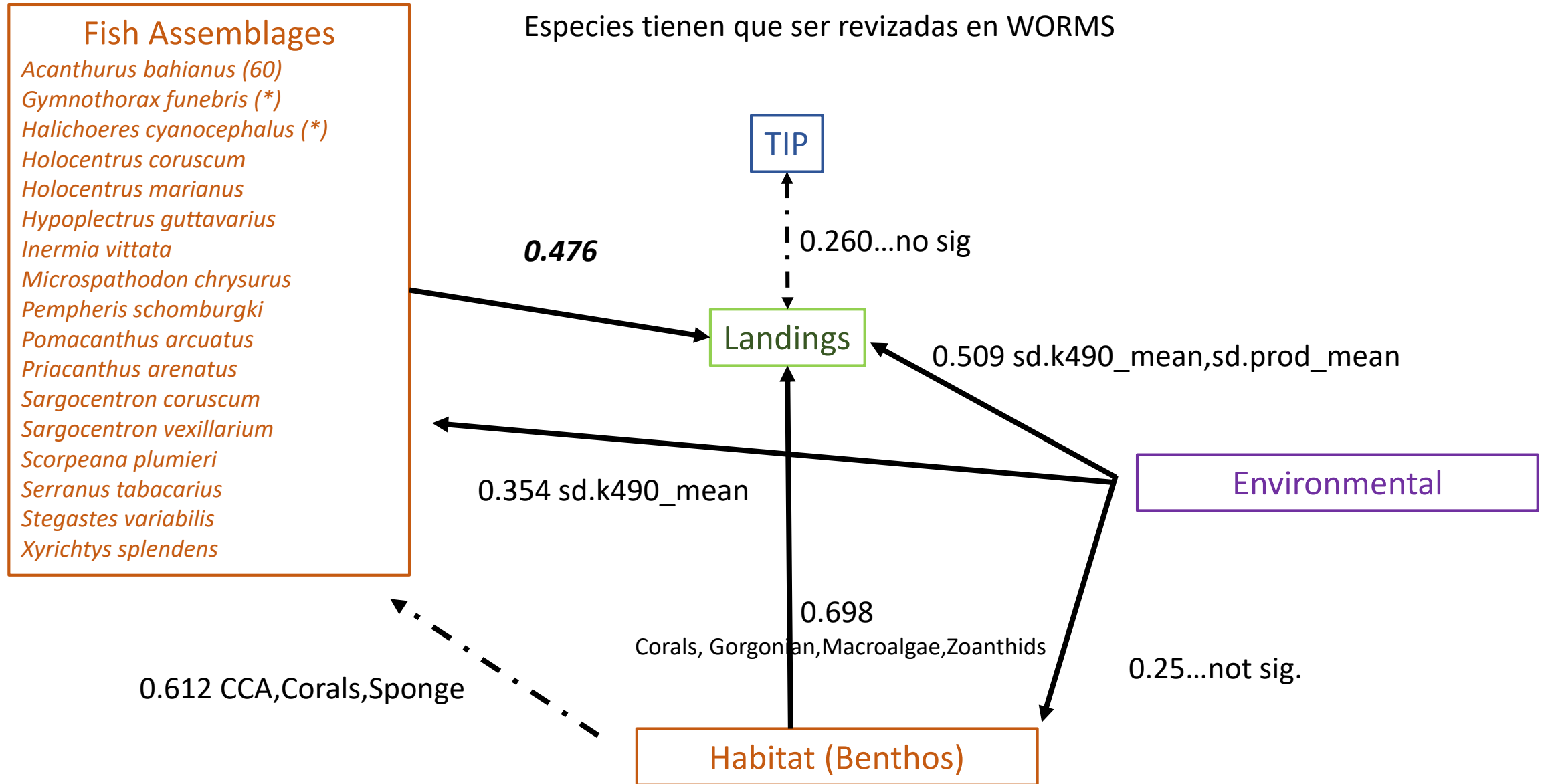
ISLAND  
■ STJ/STT  
● St. Thomas/St. John FMP

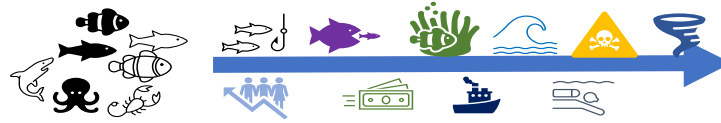


Temporal correlation structure among USCFE components (Puerto Rico)



# Temporal correlation structure among USCFE components (STT/STJ)





SO FAR....USING a multi-species approach:

- 1) Patterns of spatial and temporal variation of the landings (or any other matrix....TIP, Fish. Ind. data) can be described using the entire suite of species/groups.
- 2) Species responsible for those patterns can be described
- 3) Correlations structure can be identified among those species/groups
- 4) Changes can be measured in magnitude and direction
- 5) Reference Points can be identified in a multidimensional (i.e. multi-species) space...important to define what is important.
- 6) Need to talk (redefine?) about ACL's (or ABS or MSY) from a multi-specific point of view.

## CONCLUSIONS:

- 1) Patterns of spatial and temporal variation of the landings (or any other matrix....TIP, Fish. Ind. data) can be described using the entire suite of species/groups.
- 2) Species responsible for those patterns can be described
- 3) Correlations structure can be identified among those species/groups
- 4) Changes can be measured in magnitude and direction
- 5) Reference Points can be identified in a multidimensional (i.e. multi-species) space...important to define what is important.
- 6) Need to talk (redefine?) about ACL's (or ABS or MSY) from a multi-specific point of view.
- 7) Indicators can be identified...foundational stone of EBFM