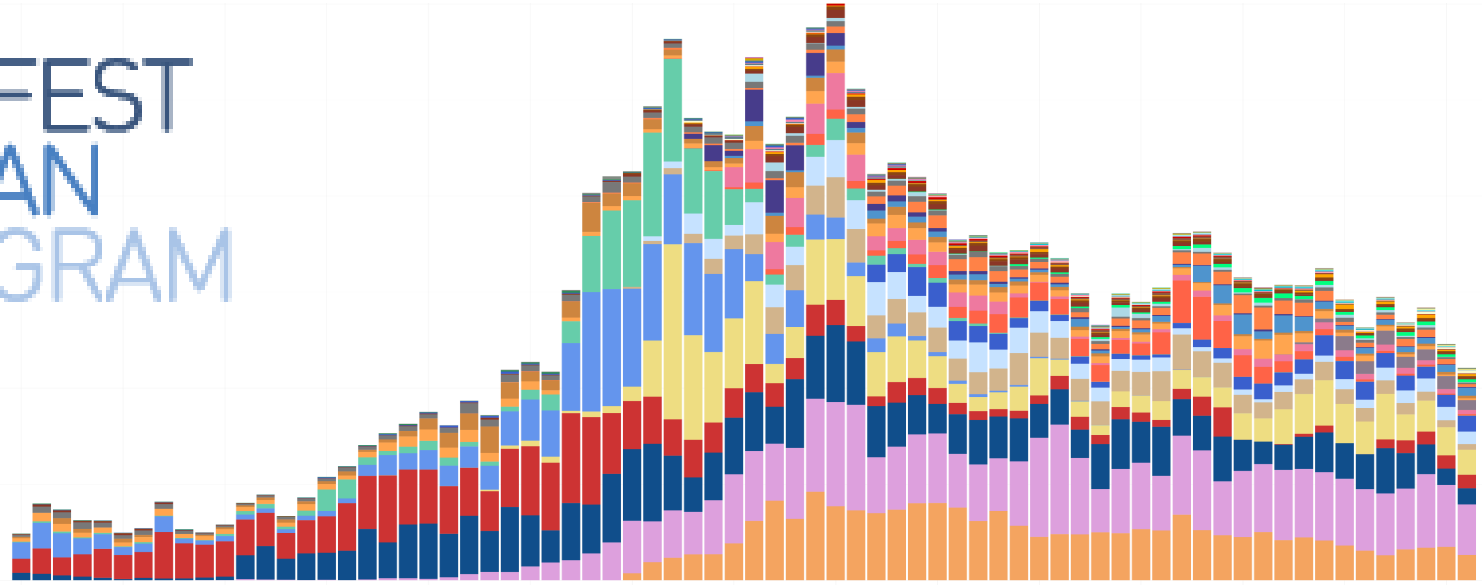
Using Portfolio Theory to Improve the Management of Living Marine Resources: *A Demonstration for the South Atlantic*



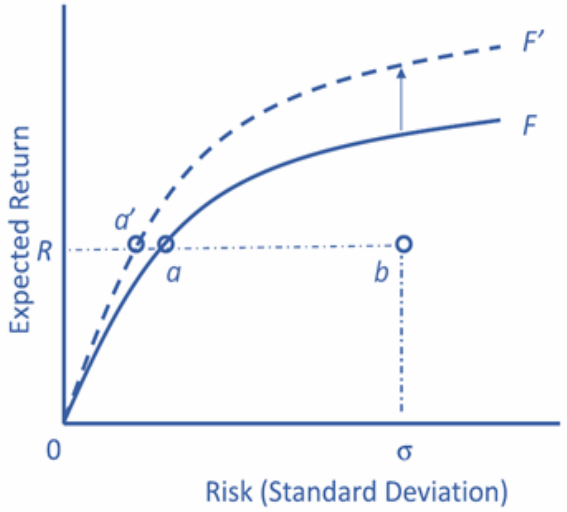
Jason Link, Fiona Edwards, Lauran Brewster, Steve Cadrin

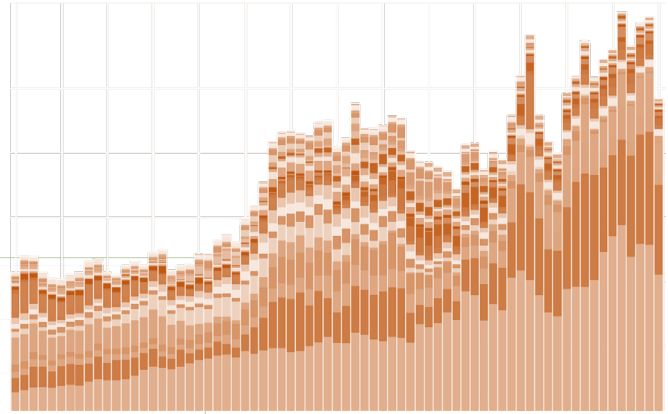
April 18, 2023

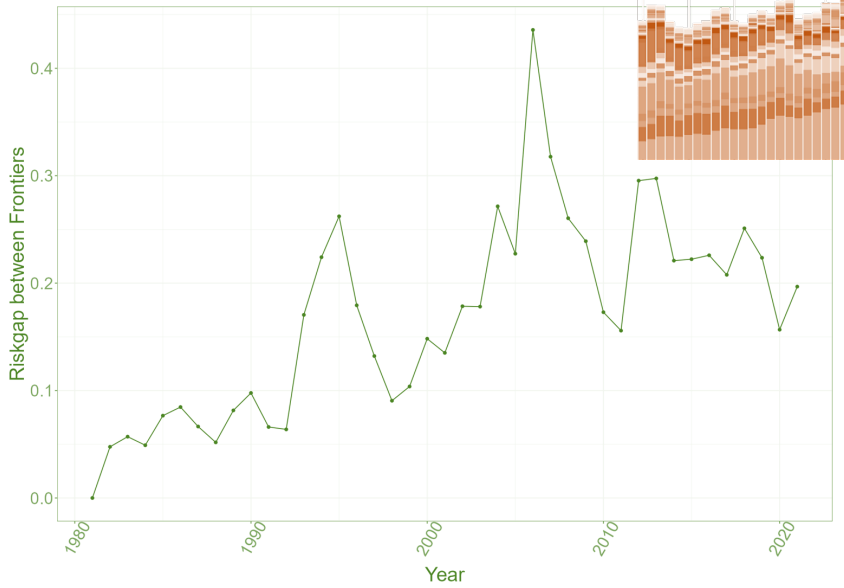
South Atlantic Fishery Management Council, Socio-Economic Panel Meeting

Outline

1. Introduction to portfolio theory · Jason Link
2. Data exploration and portfolio asset selection – Fiona Edwards
3. Portfolio results – Lauran Brewster
4. Discussion/next steps – Steve Cadrin

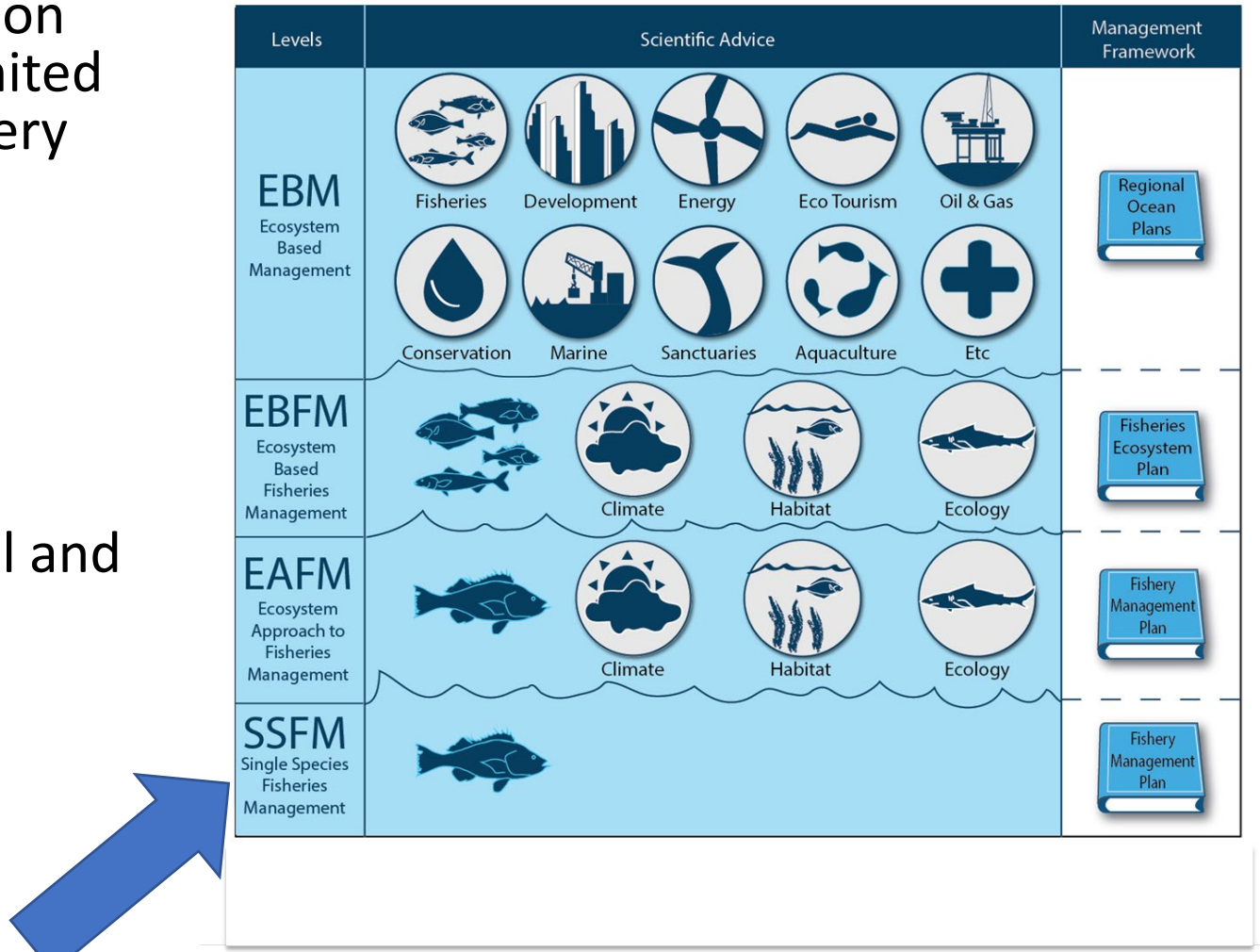






Fishery Management based on Single Species

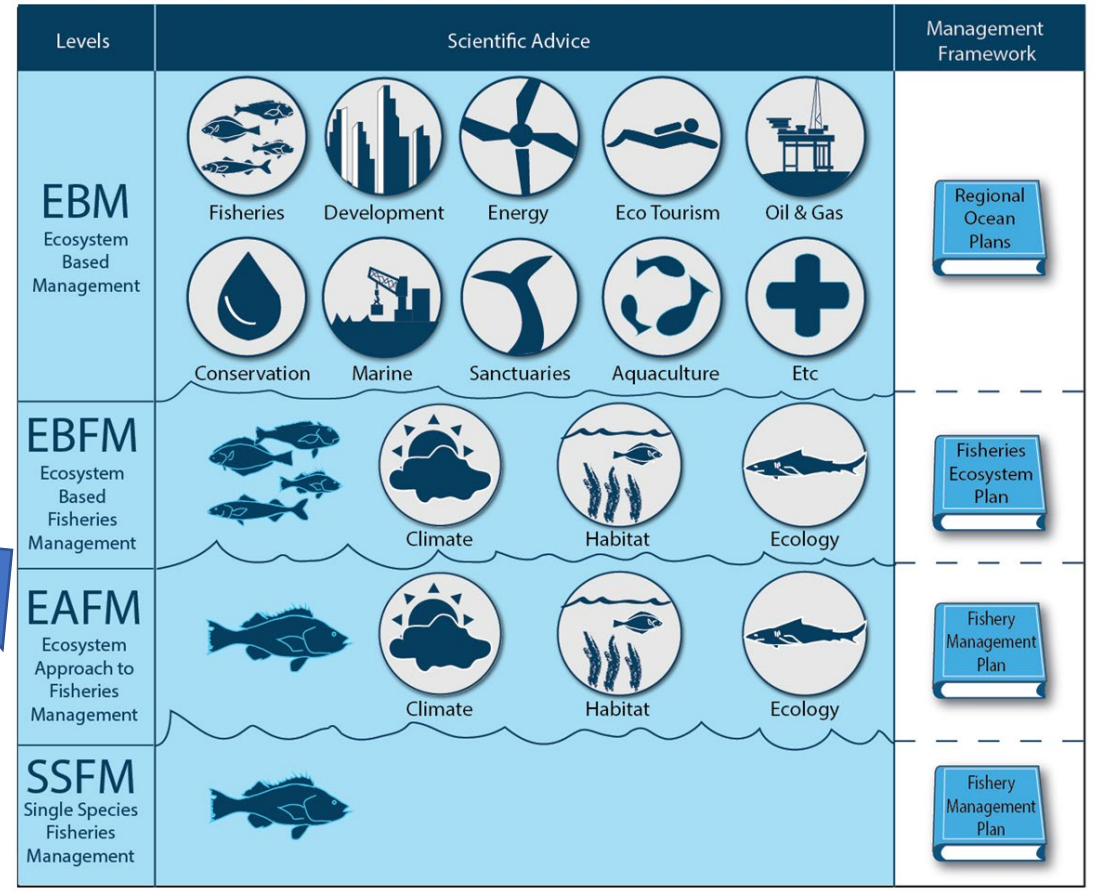
- Fishery management usually focuses on single species or populations with limited or no consideration of the entire fishery system.
- This approach has resulted in many positive outcomes, but it can be risky
- The risks extend into economic, social and even governance considerations



Ecosystem-Based Fisheries Management

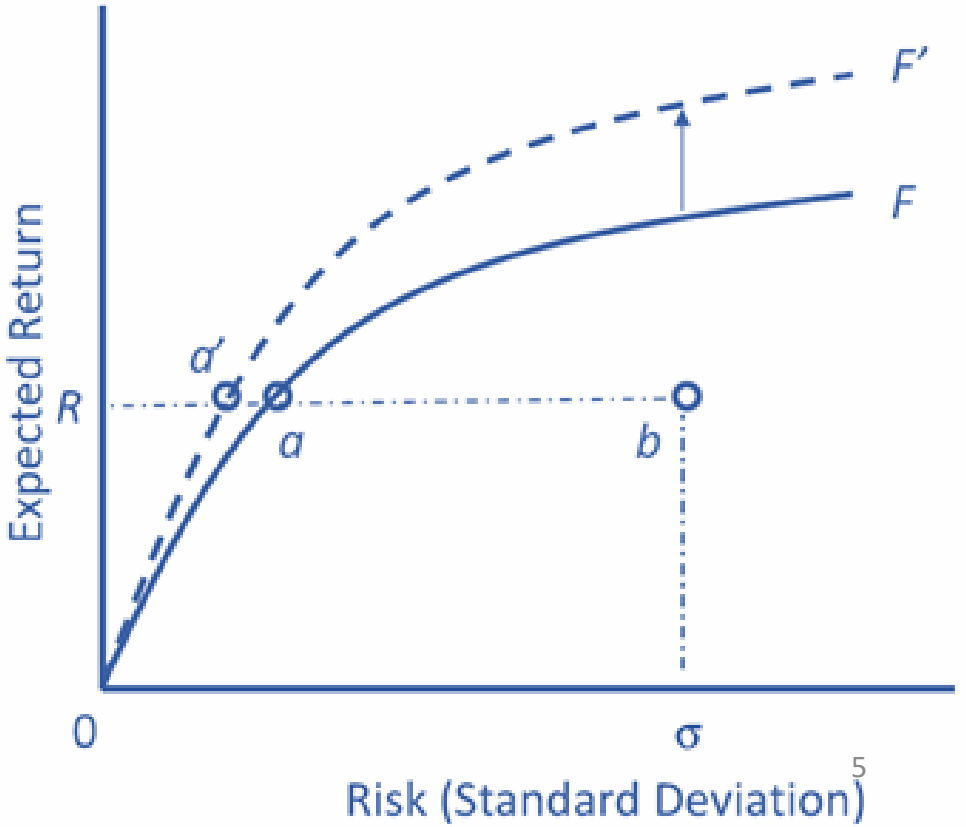
- Fishery managers are tasked with making many decisions, including harvest rates, biomass targets, and the spatial distribution of protections.

- To meet all the legal mandates for managing marine fisheries, an ecosystem approach is not only allowable, but advisable.



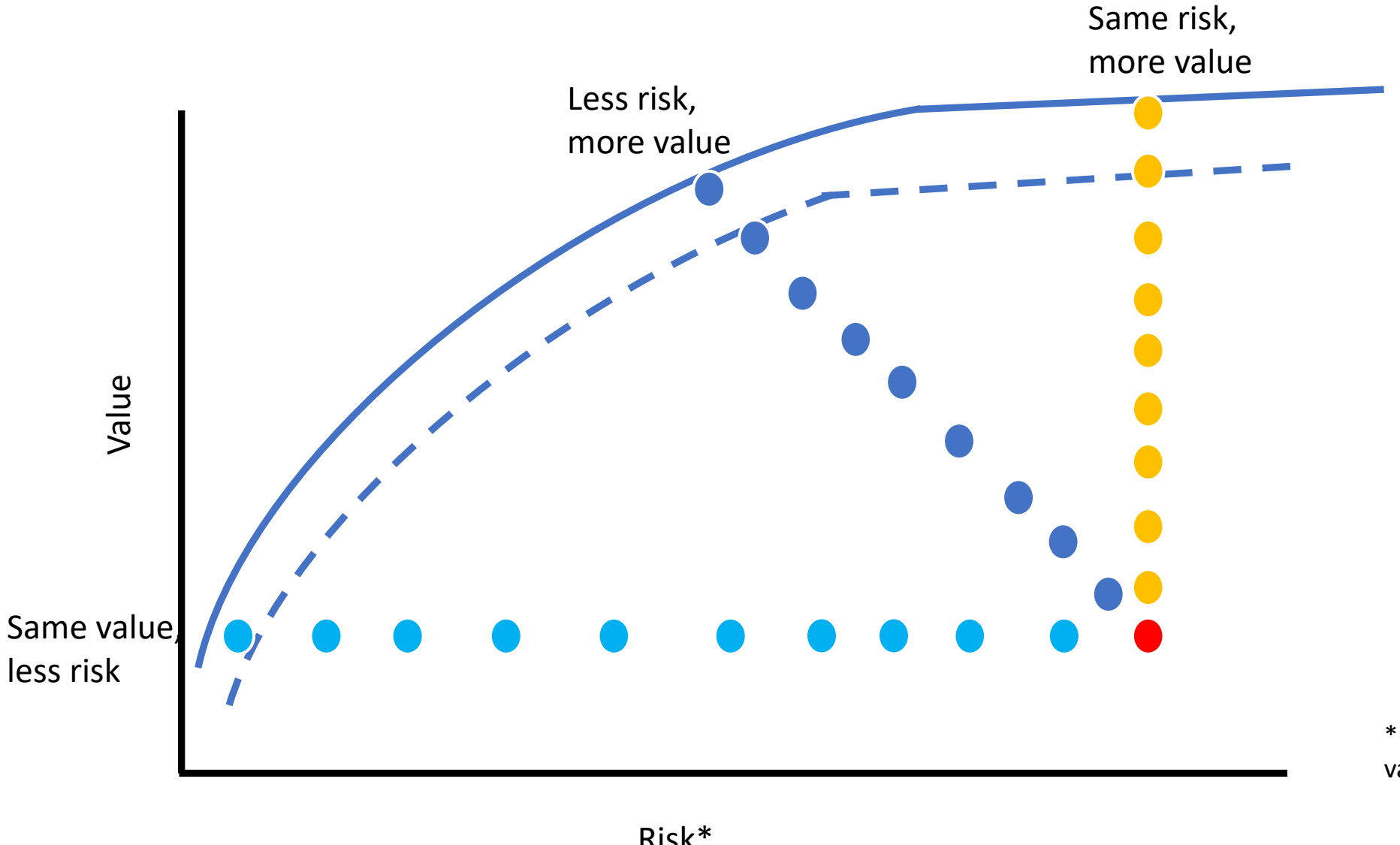
Multispecies Portfolio Management

- Theoretical studies demonstrate that the further away from the "efficiency frontier" that a set of aggregated landings is, the more risk is incurred, and the less economic yield is obtained.
- Also that more aggregated estimates of efficiency frontier (F') outperform single stock-based approaches (F)



Jin et al. 2016

- As with a financial stock portfolio, the emergent properties of a diverse portfolio of management units will be more stable than any one unit on its own.
- Theoretical studies demonstrate that the further away from the "efficiency frontier" that a set of aggregated landings is, the more risk is incurred, & the less economic yield is obtained.



*Beyond ACL, OFL, etc., but variance of value

Determining a Data Download Protocol

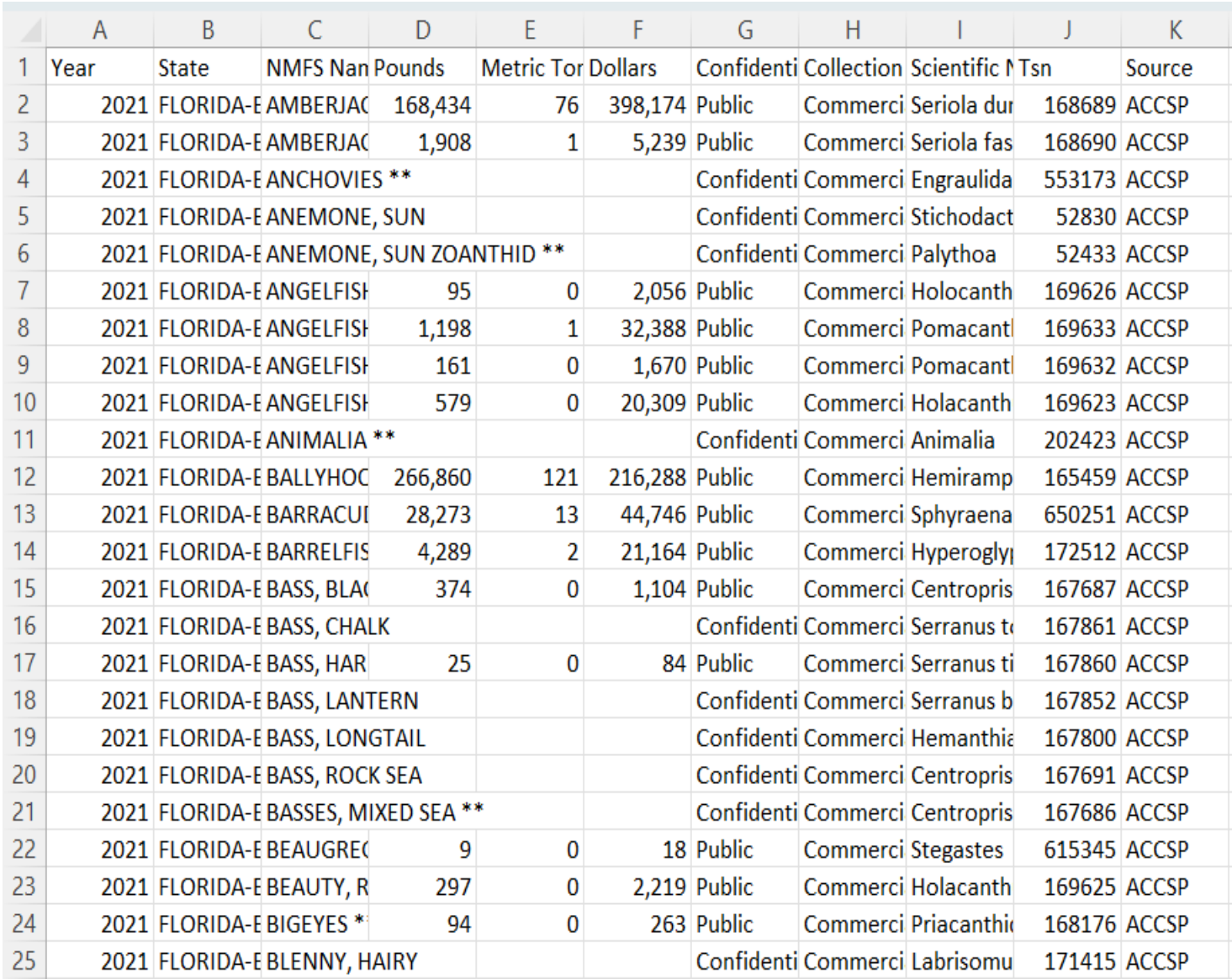
- Data Is Available for Download Online: https://www.fisheries.noaa.gov/foss/f?p=215:200:912689929330 8:Mail:NO:::

- Data Download Parameters:
  - Data Set: Commercial
  - All Years: 1950–2021
  - Region Type: NMFS Regions
  - Region: South Atlantic
  - Species: All Species
  - Report Format: Totals by Year/State/Species

As region is unable to be selected by both States and NMFS Regions for Region Type, selecting the report format as Totals by Year/State/Species allows for inclusion of state landings information for the South Atlantic

Initial Exploration of the Raw Dataset

- The raw data file has…
  - 24,340 rows, 11 columns
  - Landings for 490 unique NMFS names
  - Provides landings information for 1950 through 2021

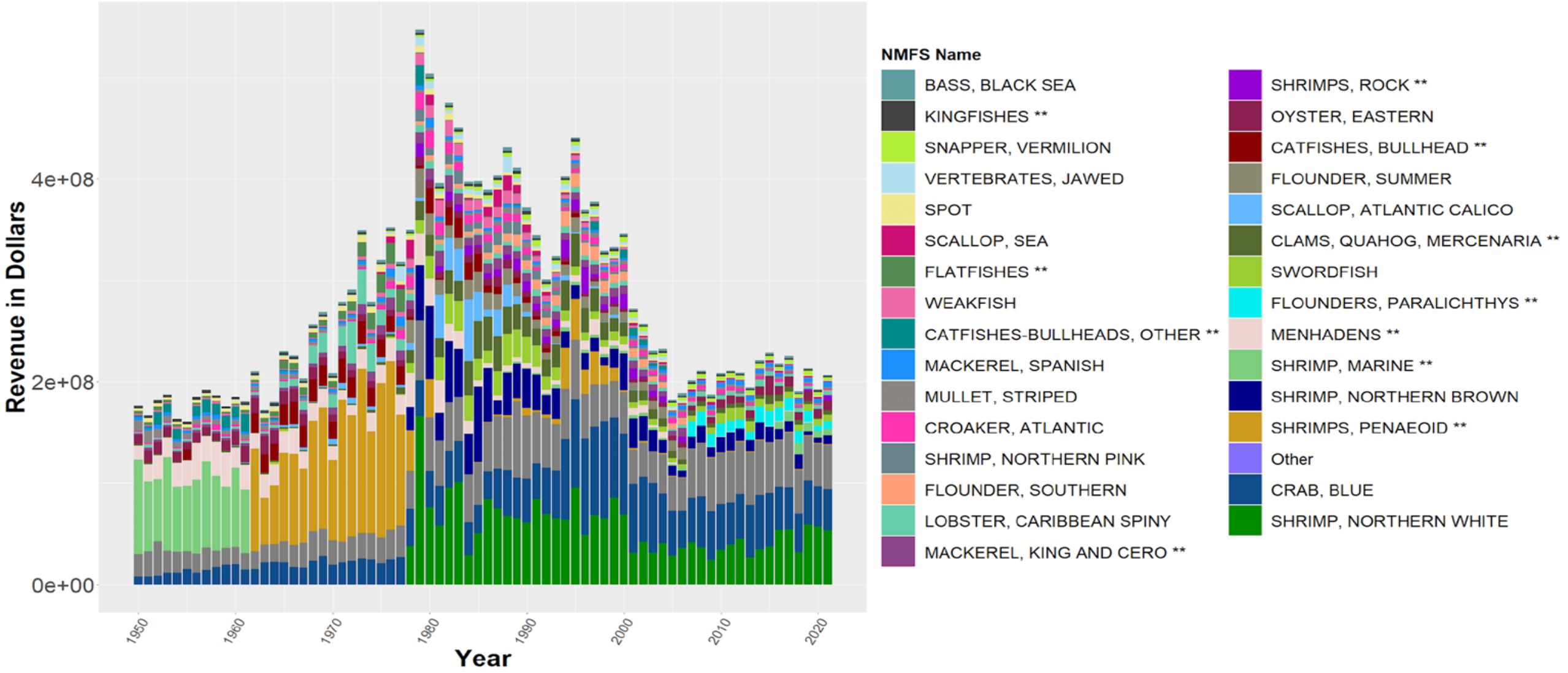


	A	B	C	D	E	F	G	H	I	J	K
1	Year	State	NMFS Nan	Pounds	Metric Tor	Dollars	Confidenti	Collection	Scientific N	Tsn	Source
2	2021	FLORIDA-E	AMBERJAC	168,434	76	398,174	Public	Commerci	Seriola dur	168689	ACCSP
3	2021	FLORIDA-E	AMBERJAC	1,908	1	5,239	Public	Commerci	Seriola fas	168690	ACCSP
4	2021	FLORIDA-E	ANCHOVIES **				Confidenti	Commerci	Engraulida	553173	ACCSP
5	2021	FLORIDA-E	ANEMONE, SUN				Confidenti	Commerci	Stichodact	52830	ACCSP
6	2021	FLORIDA-E	ANEMONE, SUN ZOANTHID **				Confidenti	Commerci	Palythoa	52433	ACCSP
7	2021	FLORIDA-E	ANGELFISH	95	0	2,056	Public	Commerci	Holocanth	169626	ACCSP
8	2021	FLORIDA-E	ANGELFISH	1,198	1	32,388	Public	Commerci	Pomacantl	169633	ACCSP
9	2021	FLORIDA-E	ANGELFISH	161	0	1,670	Public	Commerci	Pomacantl	169632	ACCSP
10	2021	FLORIDA-E	ANGELFISH	579	0	20,309	Public	Commerci	Holacanth	169623	ACCSP
11	2021	FLORIDA-E	ANIMALIA **				Confidenti	Commerci	Animalia	202423	ACCSP
12	2021	FLORIDA-E	BALLYHOC	266,860	121	216,288	Public	Commerci	Hemiramp	165459	ACCSP
13	2021	FLORIDA-E	BARRACUI	28,273	13	44,746	Public	Commerci	Sphyraena	650251	ACCSP
14	2021	FLORIDA-E	BARRELFIS	4,289	2	21,164	Public	Commerci	Hyperoglyp	172512	ACCSP
15	2021	FLORIDA-E	BASS, BLAC	374	0	1,104	Public	Commerci	Centropris	167687	ACCSP
16	2021	FLORIDA-E	BASS, CHALK				Confidenti	Commerci	Serranus t	167861	ACCSP
17	2021	FLORIDA-E	BASS, HAR	25	0	84	Public	Commerci	Serranus ti	167860	ACCSP
18	2021	FLORIDA-E	BASS, LANTERN				Confidenti	Commerci	Serranus b	167852	ACCSP
19	2021	FLORIDA-E	BASS, LONGTAIL				Confidenti	Commerci	Hemanthia	167800	ACCSP
20	2021	FLORIDA-E	BASS, ROCK SEA				Confidenti	Commerci	Centropris	167691	ACCSP
21	2021	FLORIDA-E	BASSES, MIXED SEA **				Confidenti	Commerci	Centropris	167686	ACCSP
22	2021	FLORIDA-E	BEAUGREC	9	0	18	Public	Commerci	Stegastes	615345	ACCSP
23	2021	FLORIDA-E	BEAUTY, R	297	0	2,219	Public	Commerci	Holacanth	169625	ACCSP
24	2021	FLORIDA-E	BIGEYES *	94	0	263	Public	Commerci	Priacanthi	168176	ACCSP
25	2021	FLORIDA-E	BLENNY, HAIRY				Confidenti	Commerci	Labrisomu	171415	ACCSP

Exploration of the Raw Dataset

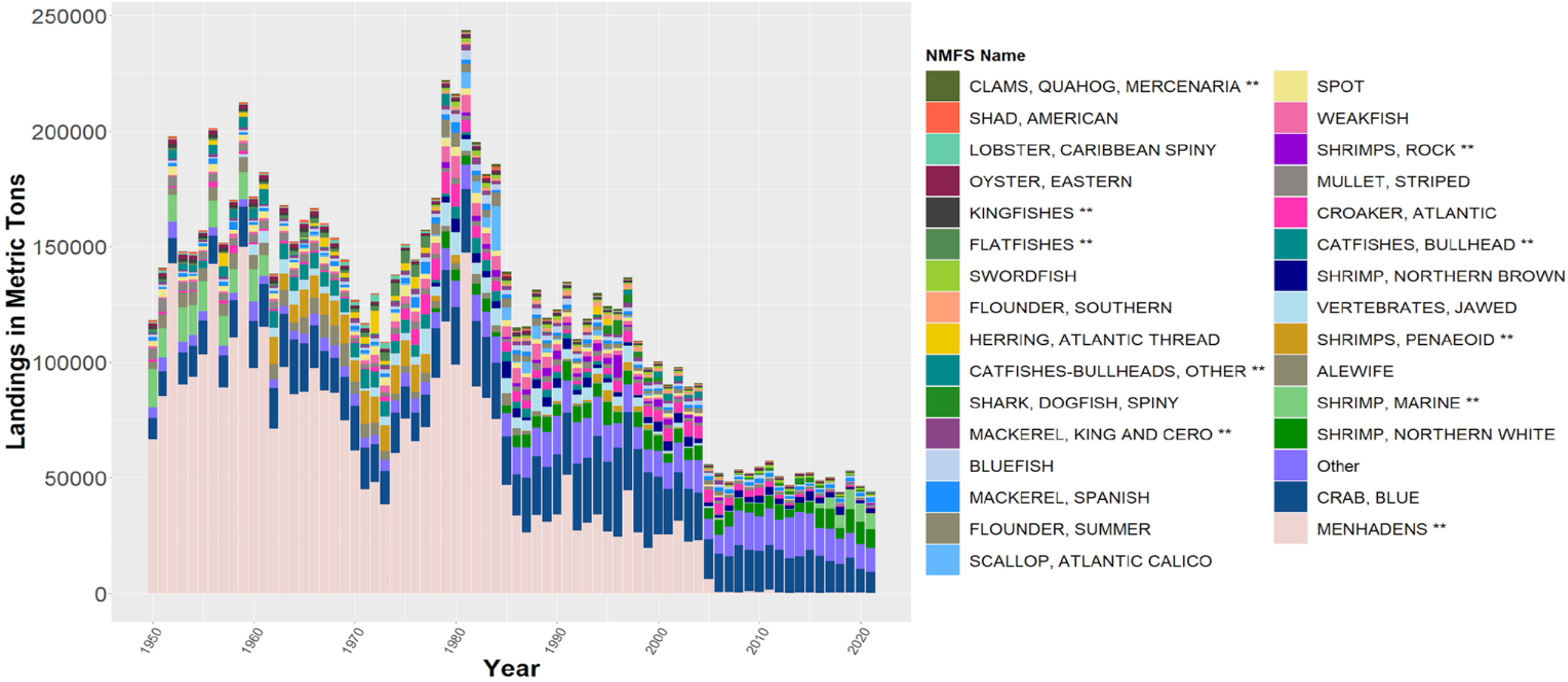
- NO RECREATIONAL REVENUE/LANDINGS. Commercial data only.
- Both public and confidential landings exist in the dataset, as confidential landings provide no landing/revenue value they were removed.
- Dataset was examined prior to manipulation in R to examine species-specific NMFS Names for some species in more recent years (i.e., Graysby Grouper having the NMFS Name “GRASBY”)
- Data gaps
  - Aggregated spp.**
    - Phased out in favor of species-specific reporting
      - e.g., CATFISHES-BULLHEADS, OTHER ** not reported since 2006
  - Withheld for confidentiality
    - *“Query results with no pounds or dollars shown indicate that landings are present in our database for the selected species but are confidential and have been grouped into "WITHHELD FOR CONFIDENTIALITY" with other confidential landings in each state”.*

The Top-Ranking Landings/Revenue



Top 30 Species by Landings Revenue in Dollars Standardized to 2021 Value, plus "Others".

Top-Ranking Landings/Revenue



Top 30 Species by Landings Weight in Metric Tons, plus "Others".

Example Portfolio Selection: Snapper-Grouper FMP

Amberjack
- Amberjack, Greater
- Amberjack, Lesser

Jack
- Jack, Almaco
- Jack, Bar

Rudderfish
- Rudderfish, Banded

Grunts
- Grunt, Cottonwick
- Grunt, Margate
- Grunt, Sailors Choice
- Grunt, Tomtate
- Grunt, White

Spadefish
- Atlantic Spadefish

Hogfish
- Hogfish

Bass
- Sea Bass, Bank
- Sea Bass, Black
- Sea Bass, Rock

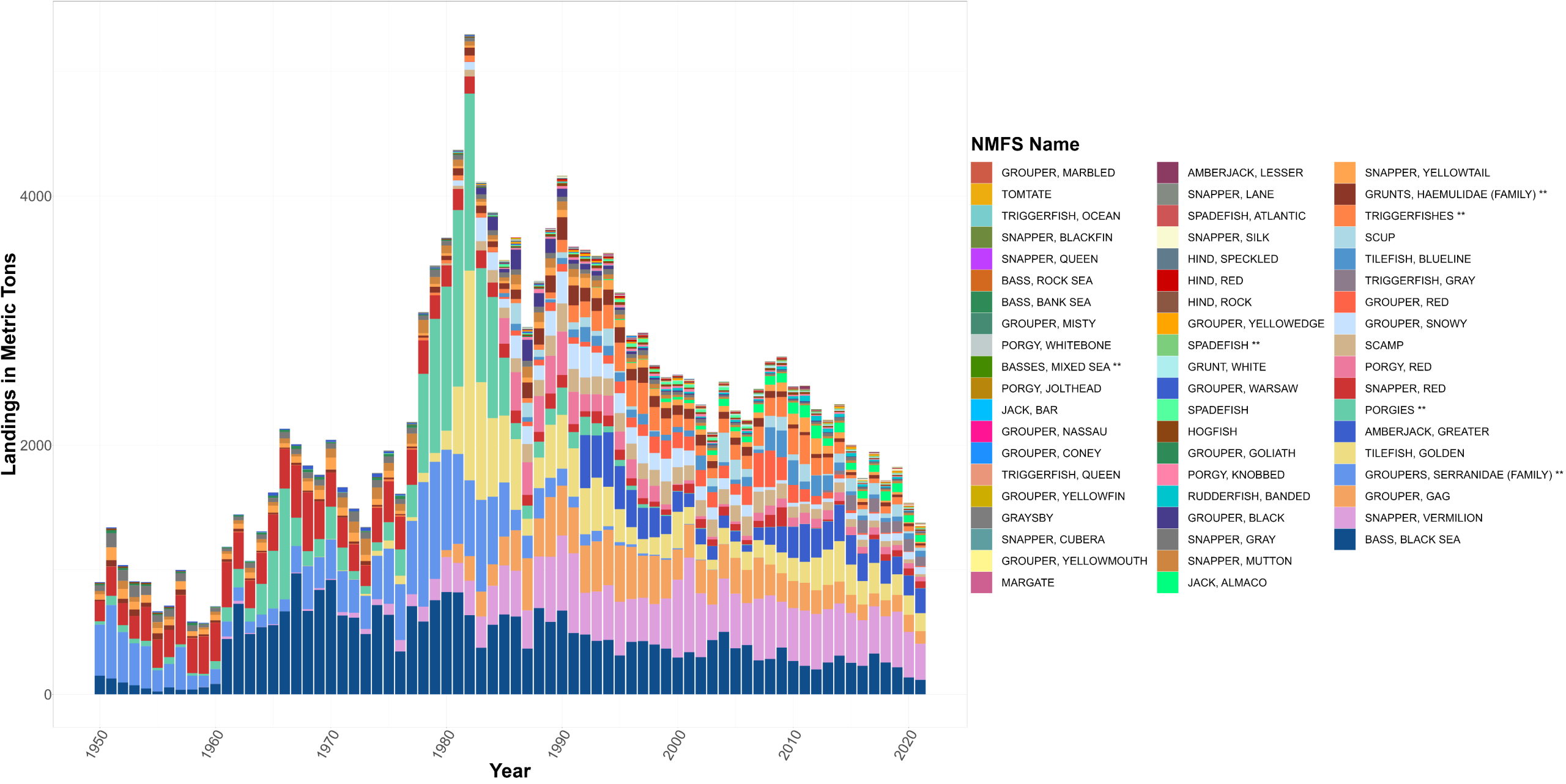
Porgies
- Porgy, Jolthead
- Porgy, Knobbed
- Porgy, Longspine
- Porgy, Red
- Porgy, Saucereye
- Porgy, Scup
- Porgy, Whitebone

Groupers
- Grouper, Black
- Grouper, Coney
- Grouper, Gag
- Grouper, Goliath
- Grouper, Graysby
- Grouper, Misty
- Grouper, Nassau
- Grouper, Red
- Grouper, Red Hind
- Grouper, Rock Hind
- Grouper, Scamp
- Grouper, Snowy
- Grouper, Speckled Hind
- Grouper, Warsaw
- Grouper, Wreckfish
- Grouper, Yellowedge
- Grouper, Yellowfin
- Grouper, Yellowmouth

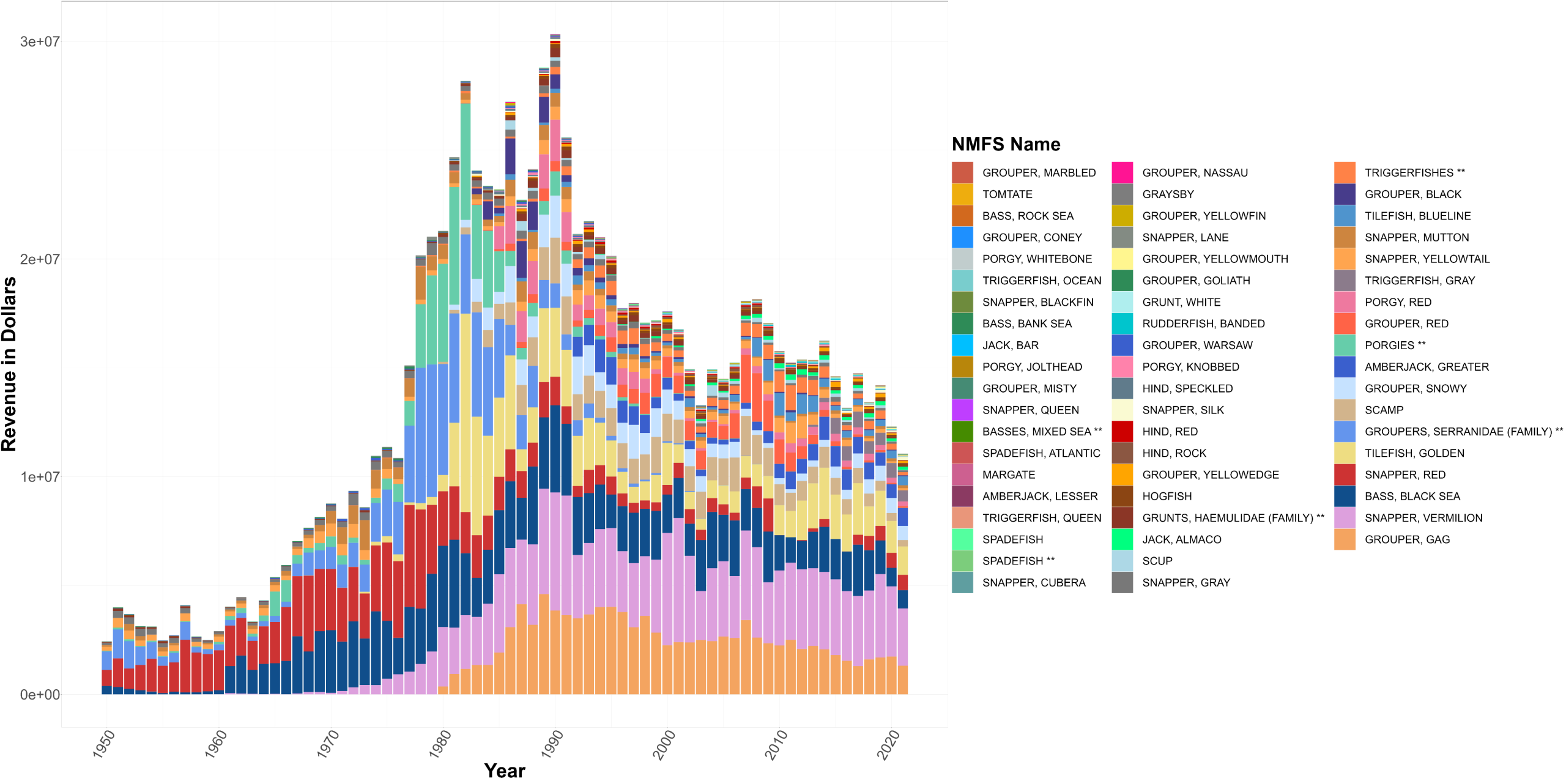
Snappers
- Snapper, Blackfin
- Snapper, Cubera
- Snapper, Gray
- Snapper, Lane
- Snapper, Mutton
- Snapper, Queen
- Snapper, Red
- Snapper, Silk
- Snapper, Vermilion
- Snapper, Yellowtail

Triggerfish
- Triggerfish, Gray
- Triggerfish, Ocean

Tilefish
- Tilefish, Blueline
- Tilefish, Golden
- Tilefish, Sand



Landings Weight (Metric Tons) for species managed under the snapper-grouper fishery management plan (FMP) by the South Atlantic Fisheries Management Council.



Landings In Revenue (Dollars Standardized to 2021 Value) for species managed under the snapper-grouper fishery management plan (FMP) by the South Atlantic Fisheries Management Council.

Data preparation prior to analyses

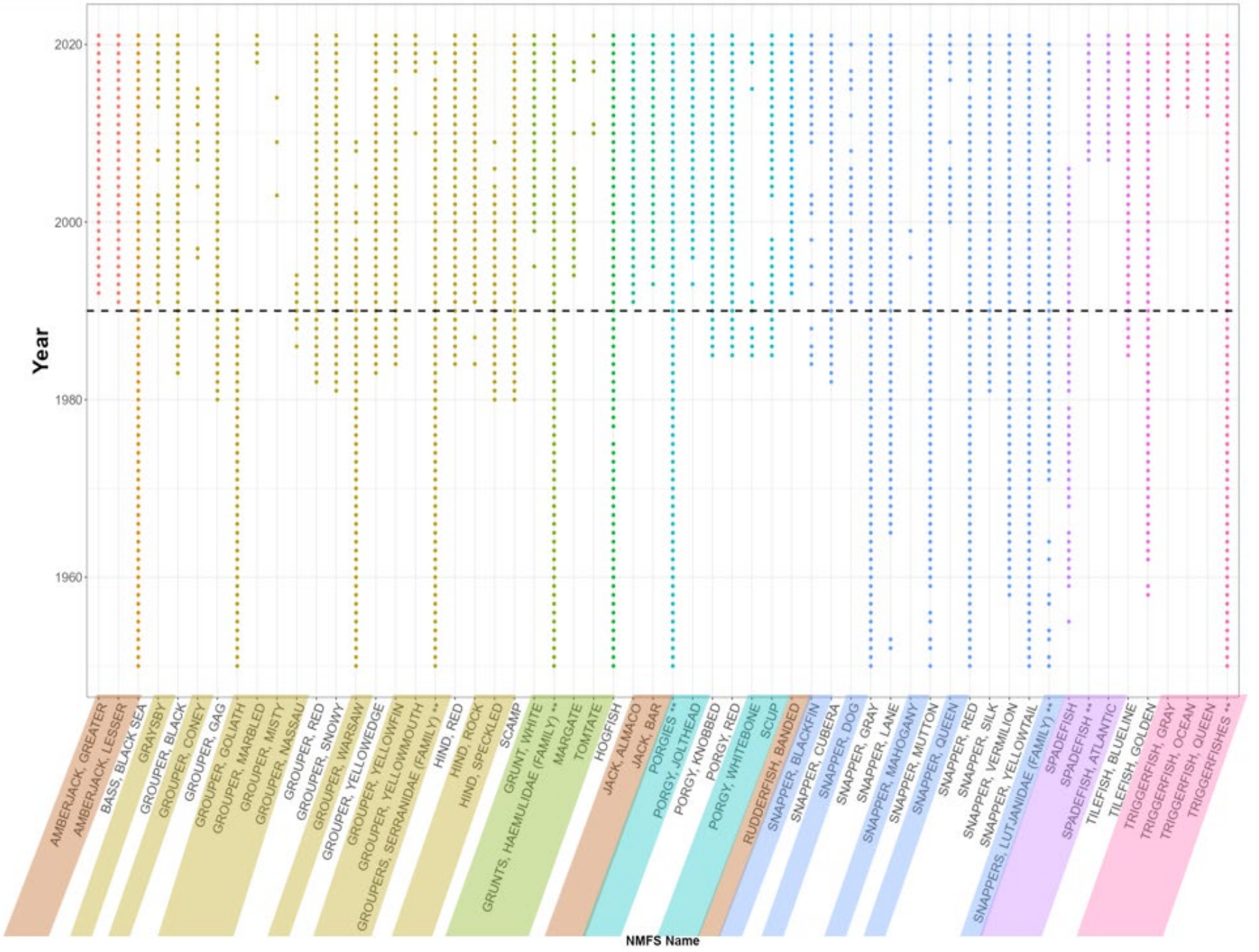
- We explored a candidate portfolio for South Atlantic Fisheries Management Council (SAFMC) species managed by the Snapper-Grouper FMP.
  - We standardized all revenue to the respective 2021-dollar value.
  - We focused on landings in metric tons to avoid zeros in landings weight records

- As frontier analysis requires consecutive years of data, we examined the presence of these species in the time series to determine if any data gaps were present.

Data preparation prior to analyses

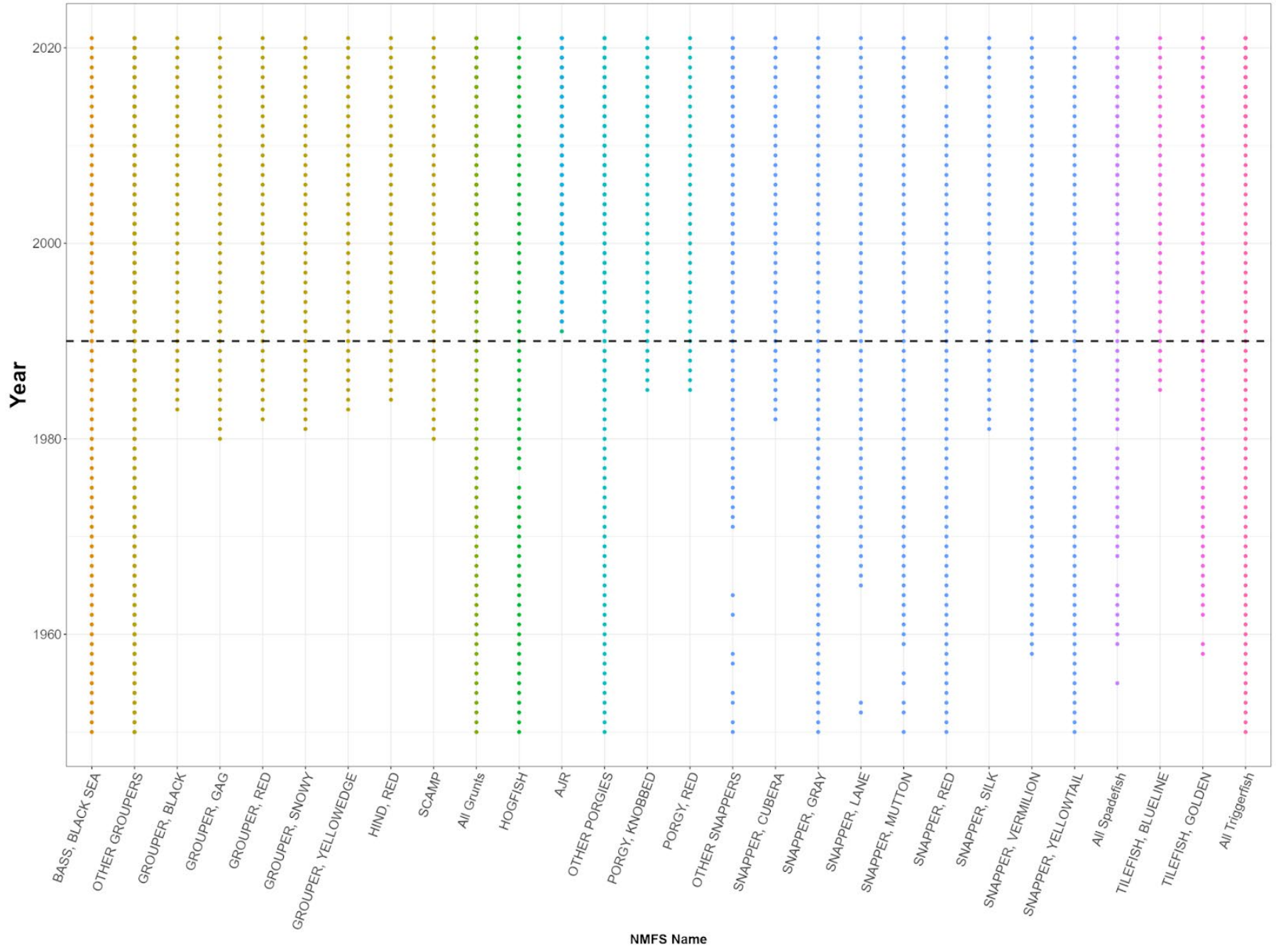
- Species with data gaps were examined further
- Five courses of action were considered for each species:

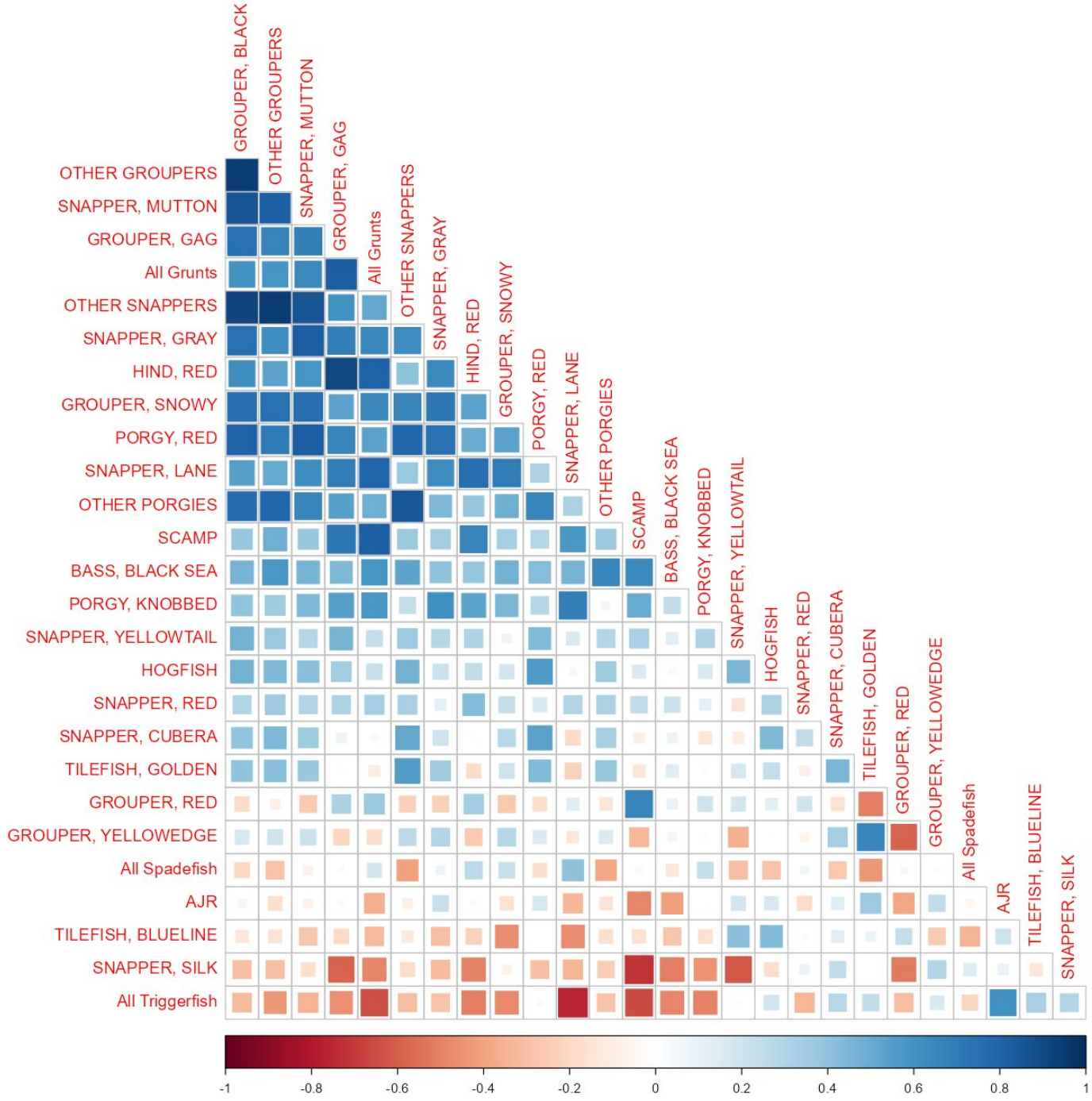
1. Aggregate
2. Truncate
3. Drop
4. Interpolate
5. Add zeros

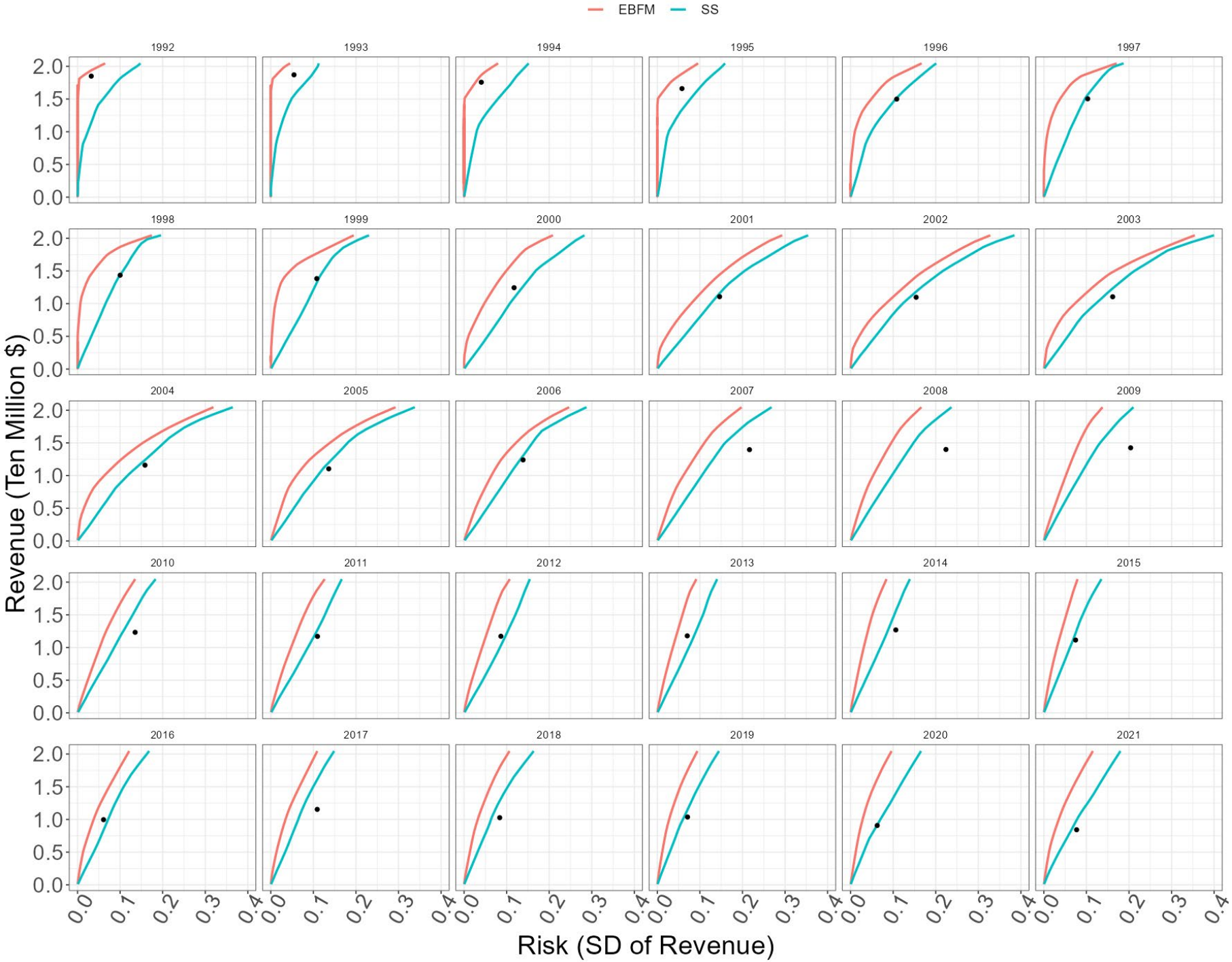


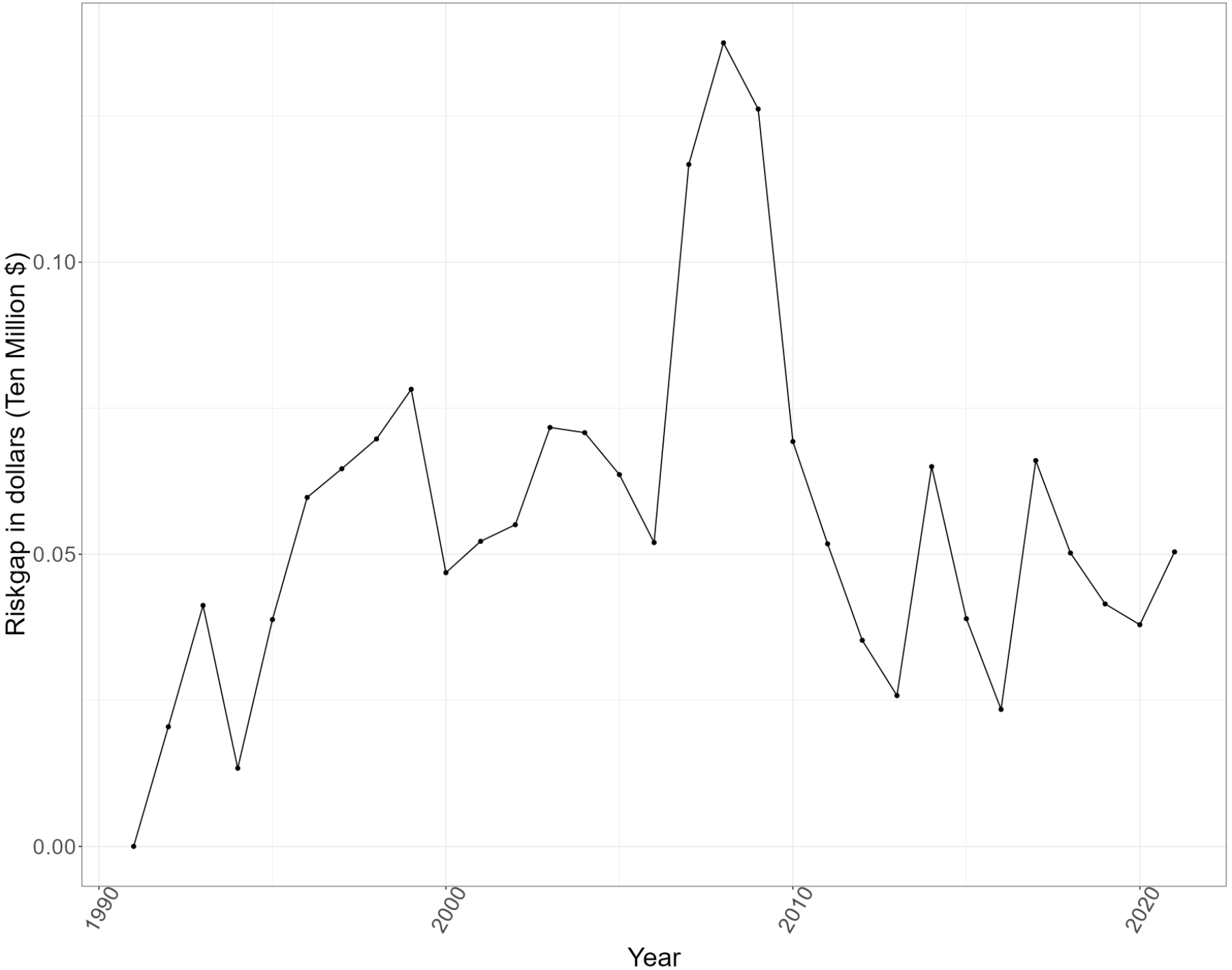
Data preparation prior to analyses

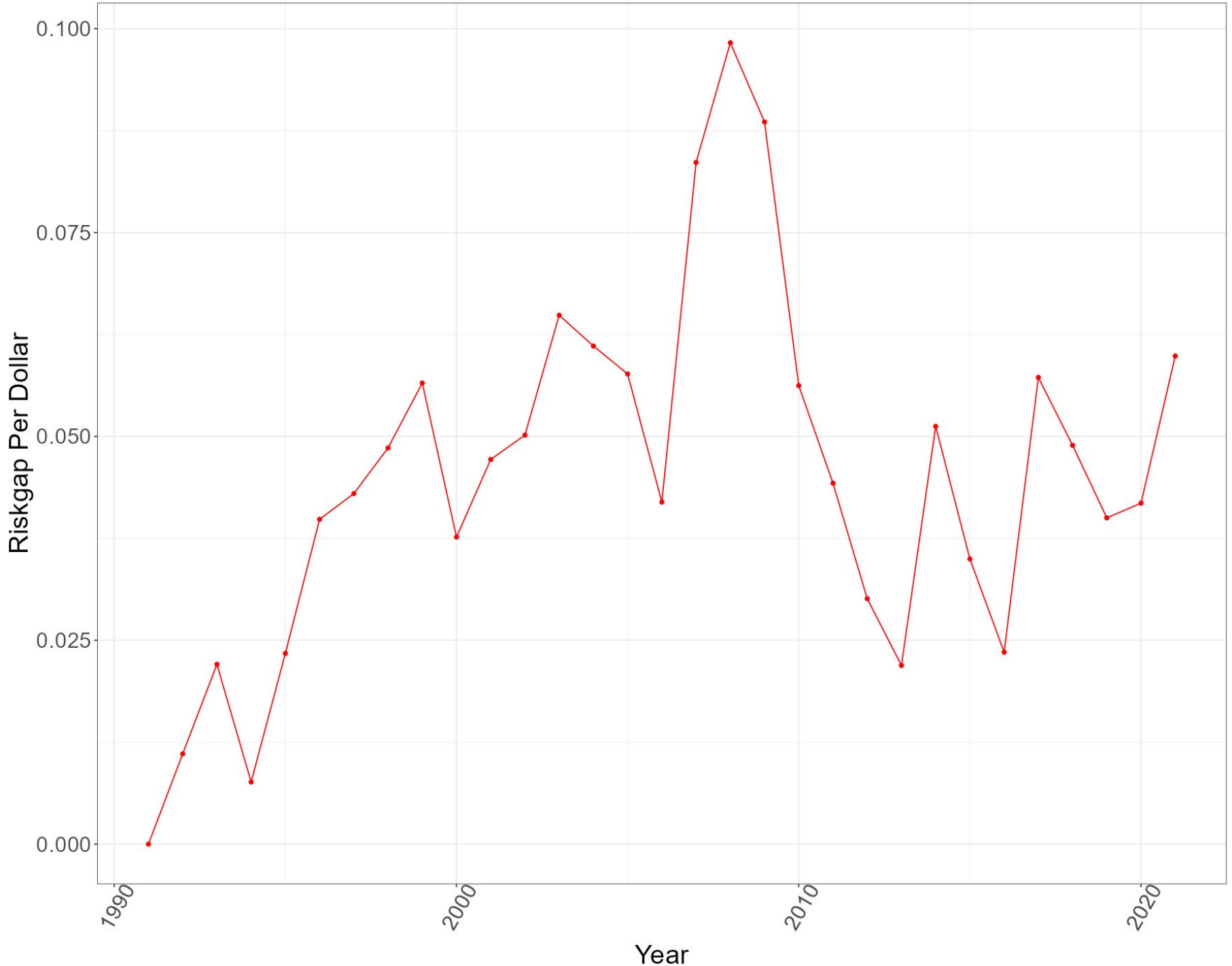
- We isolated species specific reports when available
- We dropped some species (e.g., Bass, Tilefish)
- We fully aggregated…..
  - Grunts
  - Spadefish
  - Amberjacks
  - Jacks
  - Rudderfish
- We partially aggregated…..
  - Groupers
  - Snappers
  - Porgies
- Truncated the time series to 1991

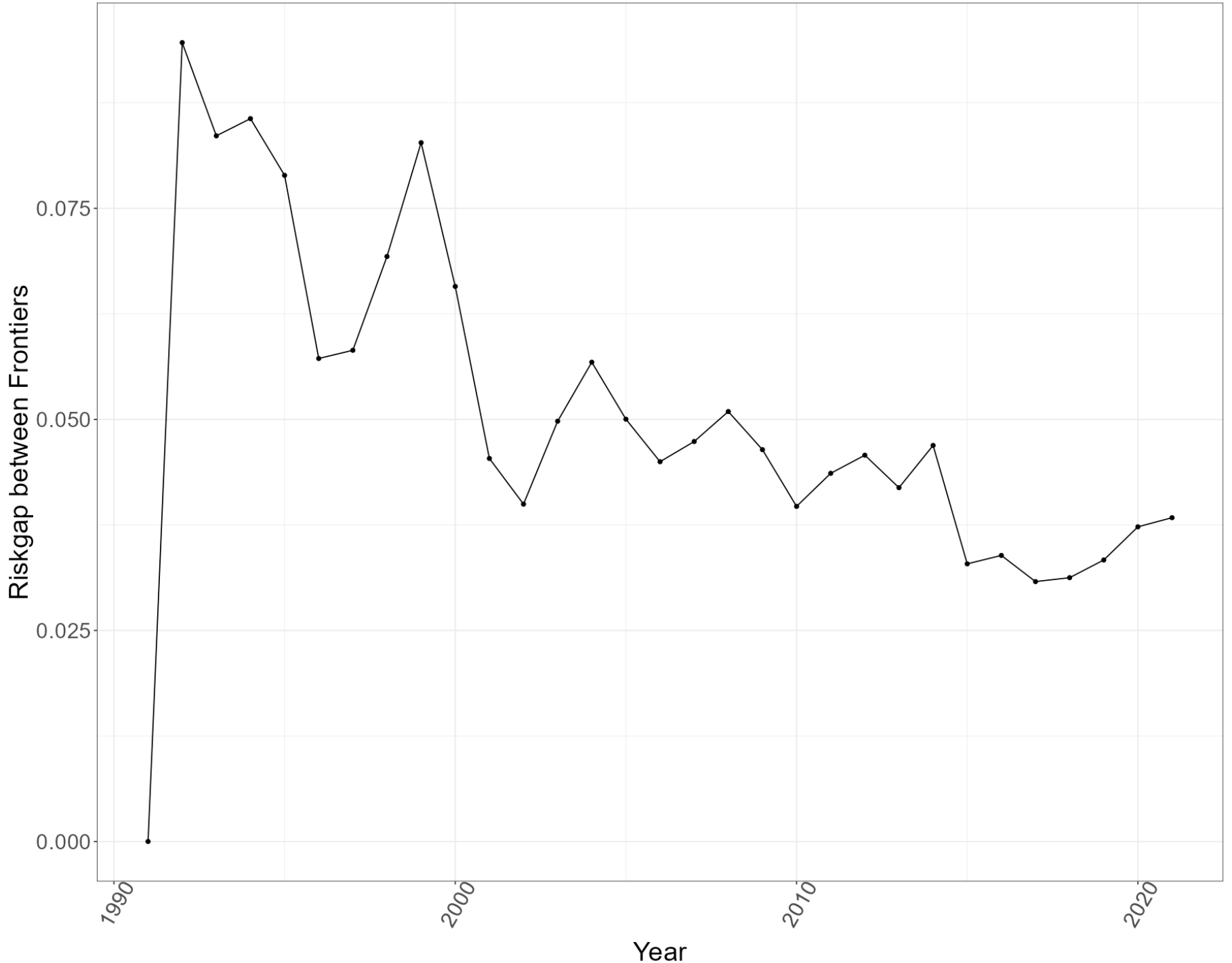


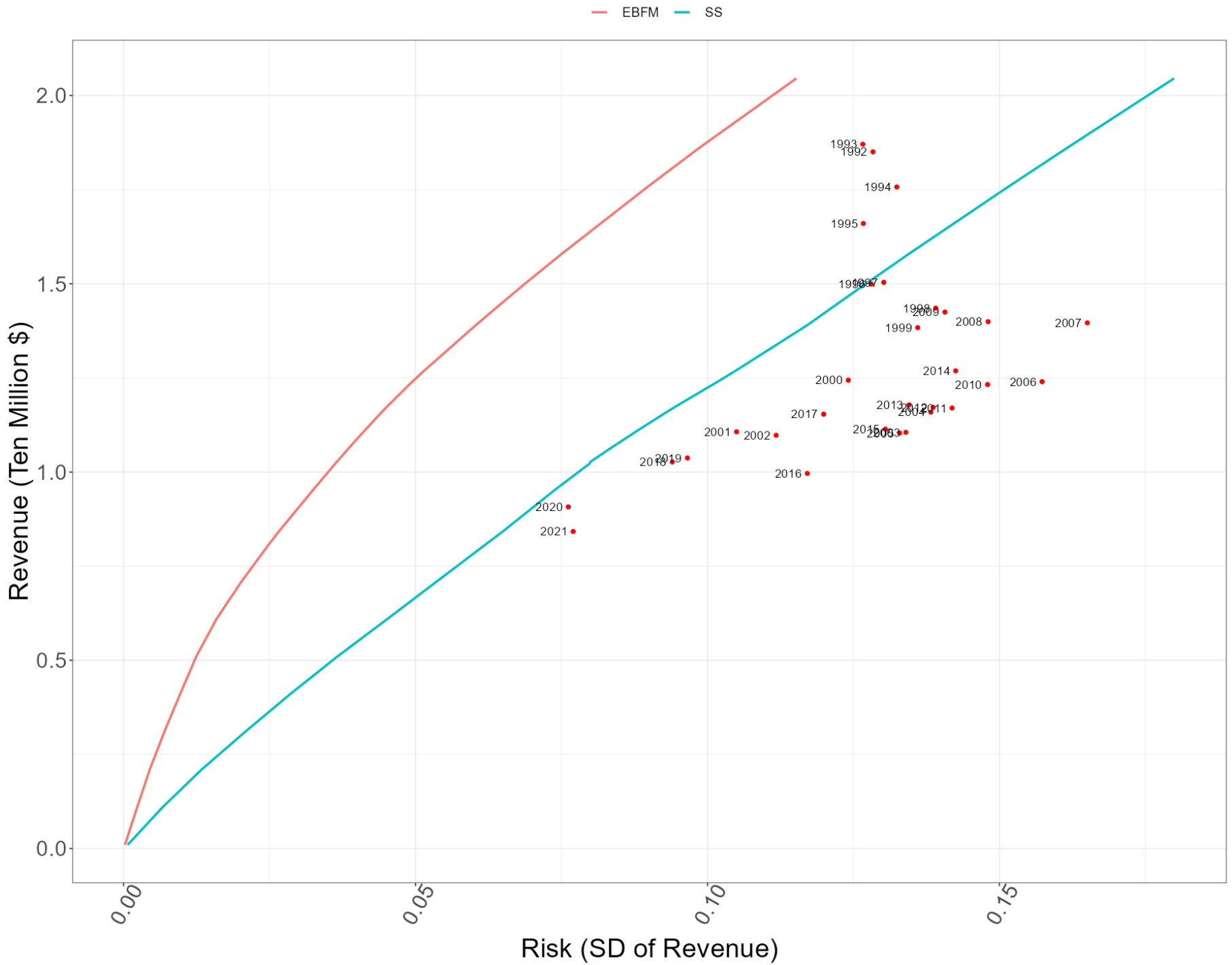

GROUPER, BLACK
OTHER GROUPERS
SNAPPER, MUTTON
GROUPER, GAG
All Grunts
OTHER SNAPPERS
SNAPPER, GRAY
HIND, RED
GROUPER, SNOWY
PORGY, RED
SNAPPER, LANE
OTHER PORGIES
SCAMP
BASS, BLACK SEA
PORGY, KNOBBED
SNAPPER, YELLOWTAIL
HOGFISH
SNAPPER, RED
SNAPPER, CUBERA
TILEFISH, GOLDEN
GROUPER, RED
GROUPER, YELLOWEDGE
All Spadefish
AJR
TILEFISH, BLUELINE
SNAPPER, SILK
All Triggerfish
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


EBFM
SS
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Revenue (Ten Million $)
Risk (SD of Revenue)


Riskgap in dollars (Ten Million $)
0.10
0.05
0.00
1990
2000
2010
2020
Year

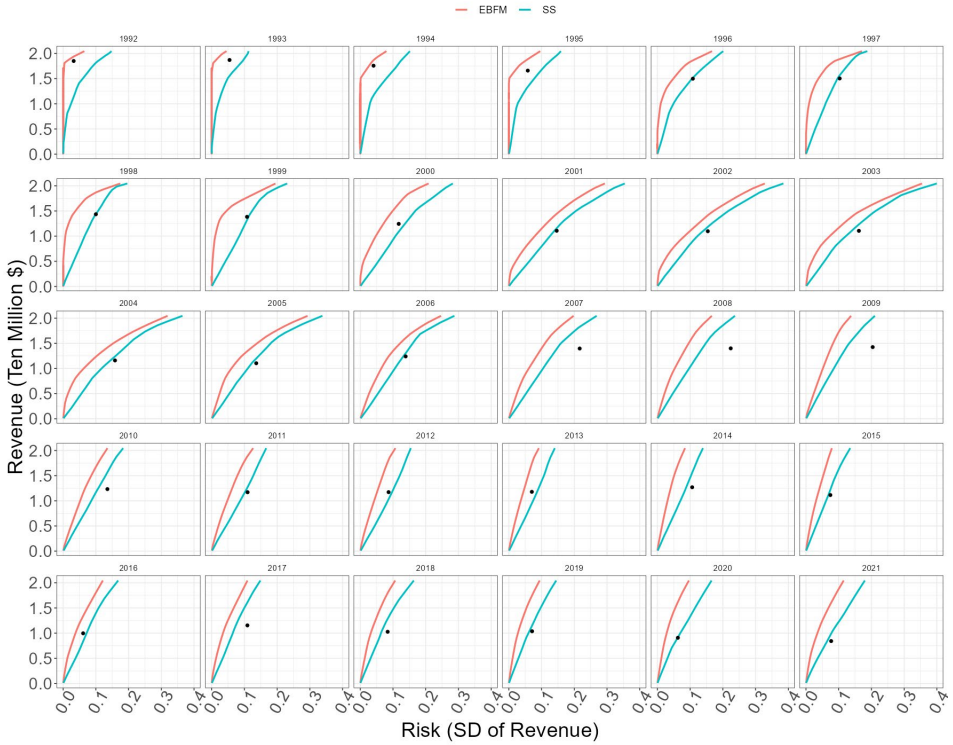

0.100
0.075
0.050
0.025
0.000
Riskgap Per Dollar
1990
2000
2010
2020
Year

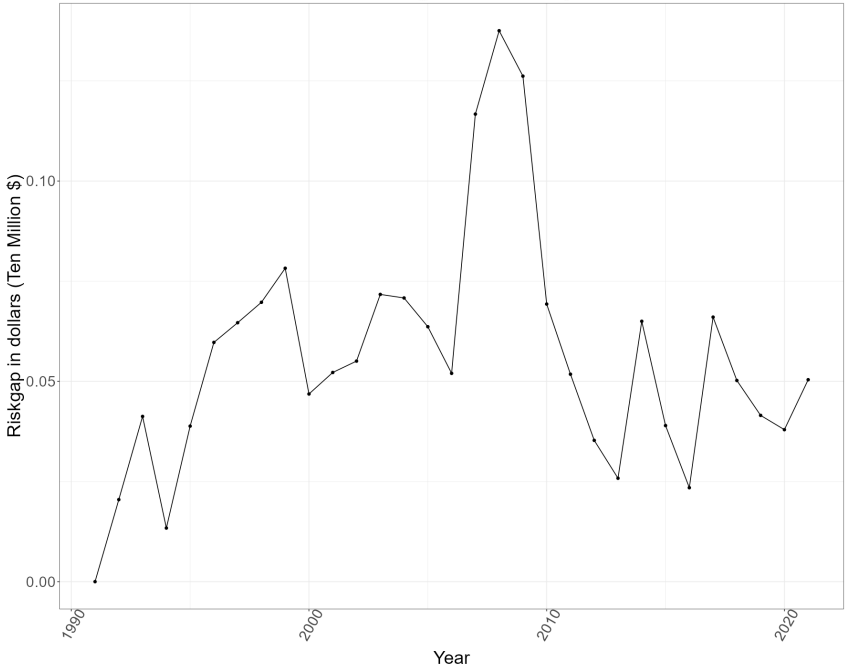

Riskgap between Frontiers
0.075
0.050
0.025
0.000
1990
2000
2010
2020
Year


EBFM
SS
Revenue (Ten Million $)
2.0
1.5
1.0
0.5
0.0
0.00
0.05
0.10
0.15
Risk (SD of Revenue)
1993
1992
1994
1995
1998
2009
2008
2007
1999
2014
2000
2010
2006
2013
2012
2011
2004
2017
2001
2002
2015
2003
2019
2018
2016
2020
2021

Interpreting Risk Gaps

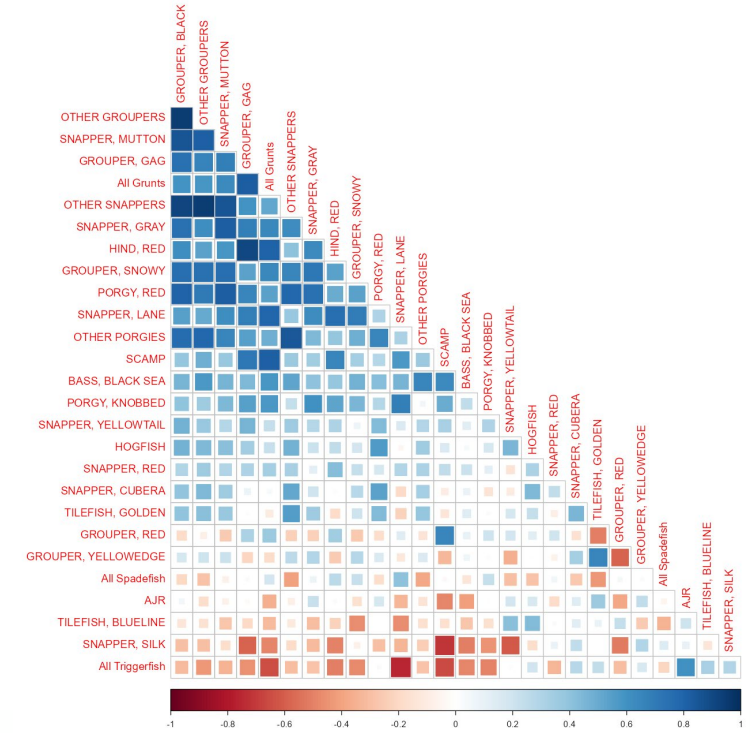
- Risk of foregone yield was greater than optimal multispecies yield.
- With more coordinated management,
  - risk could be reduced by more coordinated management, or
  - greater yield can be taken at the same risk
- The risk gap generally increased.
  - With species-specific climate effects, we should expect different trends in productivity and even greater benefits from portfolio management

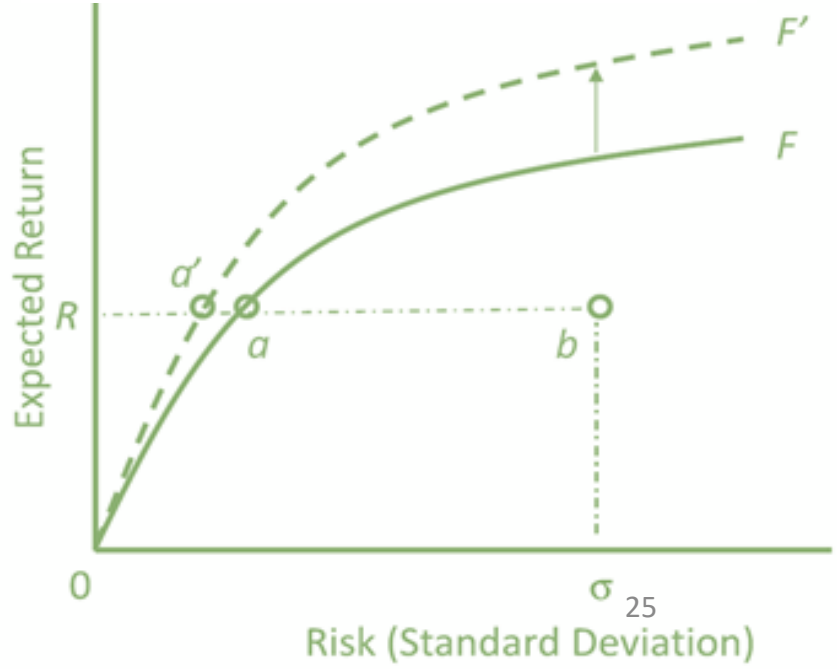




Conclusions

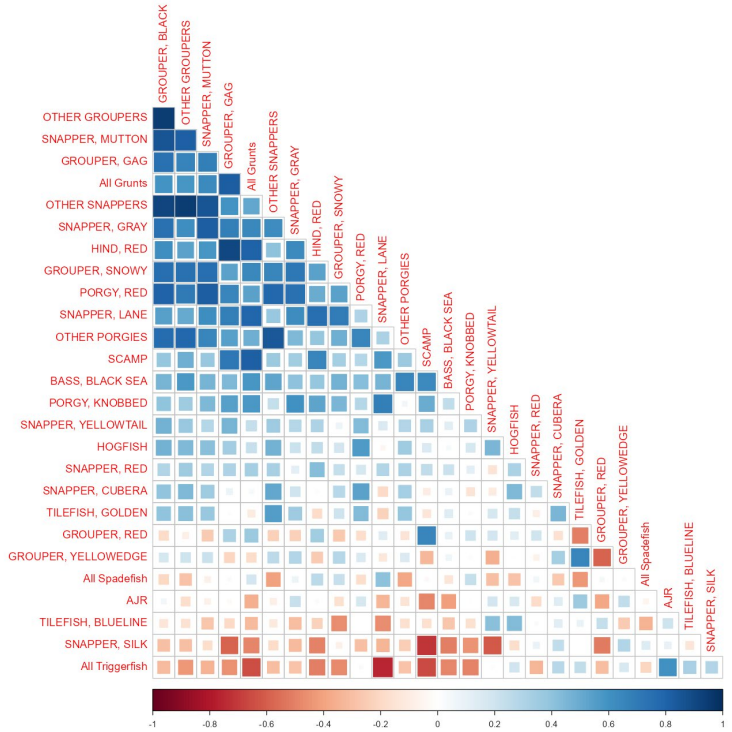
- Results suggest that portfolio diversity relies on coordinated management of snapper-grouper and other species.
  - strong positive covariance in revenue among snapper-grouper species
  - negative covariance with jacks, triggerfish, blueline tilefish, red grouper, silk snapper, spadefish.
- Frontier analysis of the snapper-grouper complex indicated that the same revenue could have been achieved with less risk of foregone yield.
- The results demonstrate that management systems benefit by allowing for flexibility to harvest abundant species by considering constraints of management strategies and tactics.

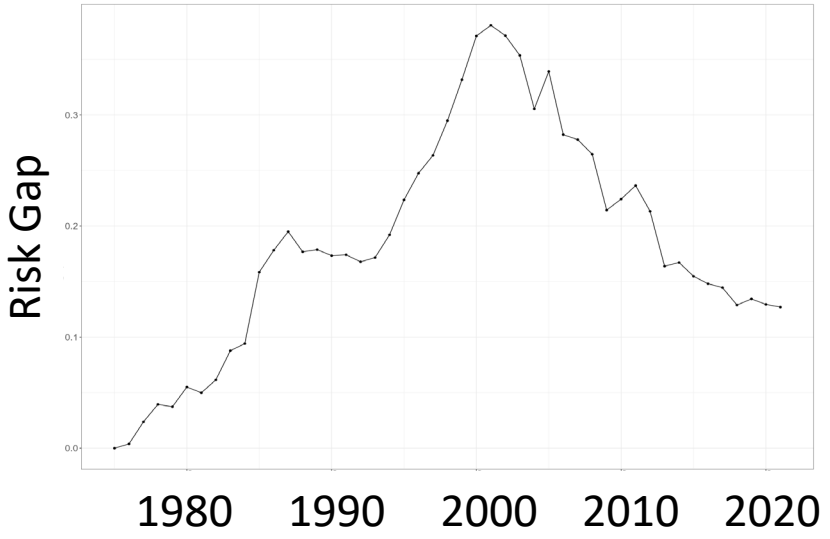




Alternative Portfolios

- The basis of portfolio management is interactions among species that produce asynchronous trends and negative covariance in annual landings or revenue:
  - technical (species caught by the same fishing gear),
  - ecological (predator-prey, competition),
  - market (product replacement), and
  - management (bycatch constraints).
- The Council could explore alternative multispecies portfolios for evaluation, e.g.:
  - Expand to include other important species that SA fishermen can target (e.g., Shrimp and the Migratory Coastal Pelagics, golden crab and spiny lobster)
  - Include recreational fisheries in the future
  - Similar diversity in covariance should produce similar results





South Atlantic Commercial + For-Hire Recreational Landings

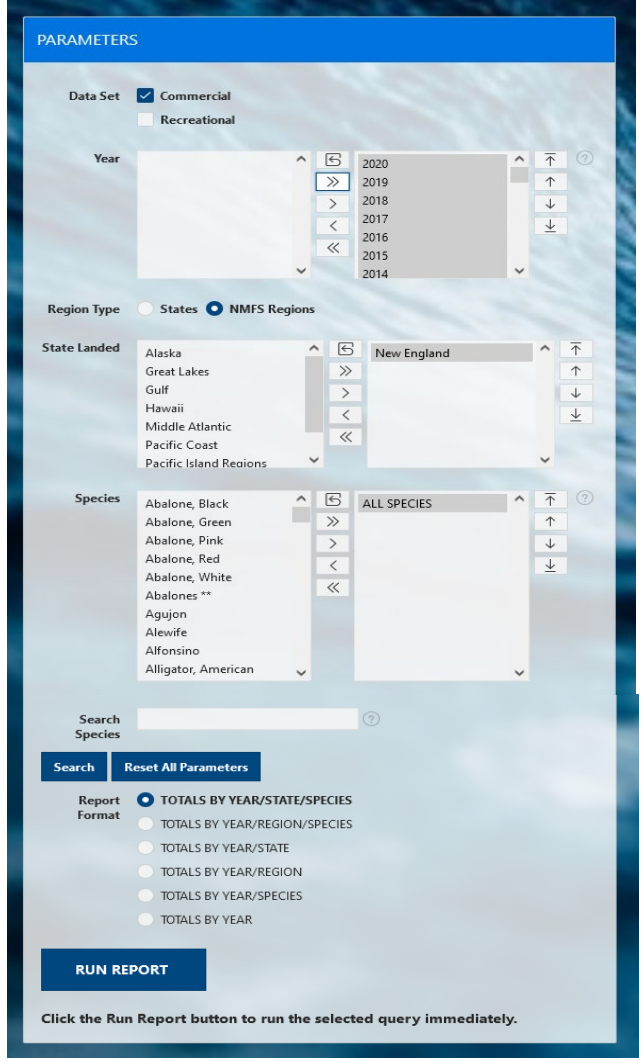
Discussion – Recreational Fishery

- Ideally, the portfolio analysis includes all catch.
- Options for demonstration project:
  1. Analysis of commercial landings only, with caveat that it excludes recreational landings and value.

  2. Analysis of all commercial and recreational landings
     1. including private boat and shore modes, using MRIP landings and dead discards
     2. evaluation of recreational value
     3. beyond the scope of the project budget and expertise

Discussion – Data Challenges

- The demonstration used publicly available data that needed extensive data processing for frontier analysis.
  - Recoding inconsistent taxa labels (phased out species aggregations)
  - Years with no landings or revenue for some taxa
  - Some records masked for confidentiality
- Solutions:
  - Truncate the time series (1991 to characterize current fishery and historical productivity)
  - Re-aggregate taxa with substantial catch (e.g., “All Grunts”, “All Spadefish” and All Amberjacks, Jacks and Rudderfish, “Other Snappers”, “Other Groupers”)
  - Add ‘true zeros’ for no landings (e.g., red snapper, 2015)
  - Exclude taxa with little catch that could not be aggregated (e.g., wreckfish, sand tilefish)
  - Interpolate confidential data gaps (not needed for this portfolio)



- Replicating these analyses with confidential disaggregated data (e.g., dealer-logbook) would provide a more comprehensive series of landings and revenue, allow for more disaggregated taxa with more covariance for optimization, and support sub-regional analyses.

Discussion – Modeling, Next Steps & Thanks

- Convergence of frontier analysis is constrained by time decay factors, maximum annual catch per species, etc.
  - We're in the process of evaluating sensitivity of risk gaps to portfolio composition, time series, etc.
  - We welcome suggestions to improve optimizer tolerance and precision.
- Acknowledgments:
  - Funding from the Lenfest Ocean Program
  - Steering Committee: Howard Townsend, Geret DePiper, Lisa Kerr, Jeffrey Buckel, Douglas Lipton, John Walden, Chip Collier, Christopher Dumas, Scott Crosson, Michael Ruccio, and Rob Griffin.
  - Special thanks to Howard Townsend and Geret DePiper for help with frontier analyses.