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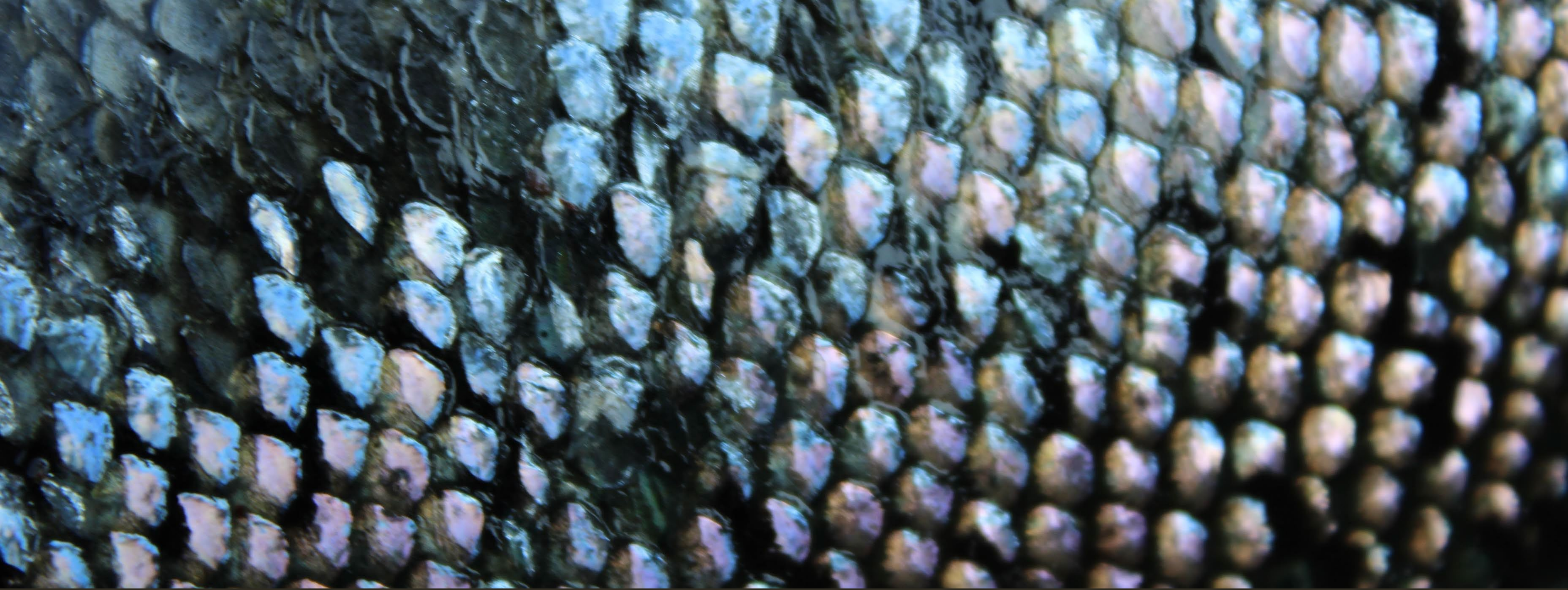
Quantifying Extinction Risk in Commercial Marine Species

Rondi Nordal
Western Washinton University



QUANTIFYING EXTINCTION RISK IN COMMERCIAL MARINE SPECIES

Rondi Nordal[1] , Ed Tekwa [2], and Juan Bonachela [2]
[1] Western Washington University
[2] Rutgers University

GREATER CONTEXT OF MY PROJECT

- This is a summary of a 10-week summer research internship at Rutgers University through a National Science Foundation funded program called RIOS.
- The goal of this project was to explore the role of overharvest in species extinction and to identify relationships between economic and ecological characteristics. Ideally this could be widely applied, not limited to commercial marine species.
- My direct advisor, Ed Tekwa, released a paper[1] in PNAS that modeled institutional path dependence and alternative stable states of conservation or depletion. My research is an extension of this and uses similar data.
- Ed and Juan Bonachela, another advisor, are currently working on a modeling project assessing species extinction risk given how quick institutions are to respond to changes.

BACKGROUND

- Many species around the world are at risk of population decline due to threats such habitat loss and climate change.
- Commercially harvested species are also at risk of overharvest, which happens when populations are harvested faster than they can reproduce.
- We hope to learn more about the relationship between economic and ecological drivers of overharvest in order to better manage resources and conserve species diversity.
- If we identify clear relationships, we could learn how to better predict extinction risk.

MORE BACKGROUND

- We used terms and values to represent economic and ecological factors.
  - Economic value: ((cost+subsidy)/landed value)
    - This is based on previous research conduced by my advisor in the PNAS paper[1].
    - Cost represents the expenses associated with running a fishery such as maintaining vessels and gear
    - Subsidies are paid by the government to ensure fishing activities can continue even if the costs are high
  - Potential Productivity: maximum sustainable yield (MSY)
    - This is an ecological measure of the largest harvest that retains a sustainable population. We took the natural log of this value to make it easier to represent and understand.
    - Extinction as defined by ecological collapse of a species.

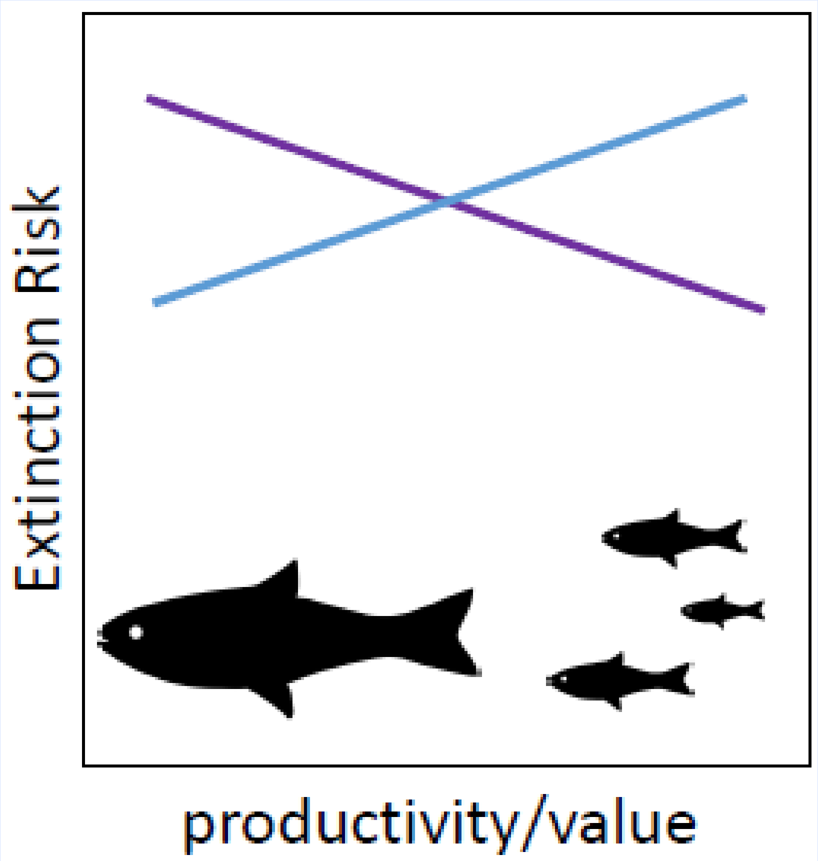
DATA

- We used fisheries catch data (Maximum Sustainable Yield, MSY) from the RAM Legacy database and matched species with threatened status as listed in data from the International Union for Conservation of Nature (IUCN). We also matched fisheries with economic data based on region.
  - The datasets used several different units that include fish species and fish stocks. A stock is a regional, genetic, or economic subset of the species. For example, sockeye salmon caught in Alaska and in Washington are the same species, but may be recorded and managed as separate stocks.
  - We also used economic data from a paper by Lam et. al (2011)[3] and matched country data to regions listed in the RAM data. The economic data used includes landed value, variable costs, and subsides.

HYPOTHESES

- The two main questions we had related to how extinction risk changed with the economic value based on trends observed with the combined economic and ecological Productivity Index (PI) of productivity/value.

1. Does extinction risk increase with the PI?
   - More productive but less valuable species are at greater risk
   - This is based on Tekwa et. al (2019)[1]
2. Does extinction risk decrease with the PI?
   - Less productive but more valuable species are at a greater risk
   - This is based on Dasgupta et. al (2019)[2]



DATA

- RAM Legacy Stock Assessment Database:
  - We used this dataset to get MSY data to represent productivity. I also used species name to match with IUCN data and stock region to match with the economic data which was organized by country.
- IUCN Red List
  - We used this to collect known threat status data as a representation of extinction risk by species.
- Lam et. al (2011)[3]
  - We used this to collect economic data such as landed value, variable cost, and subsidies organized by country.

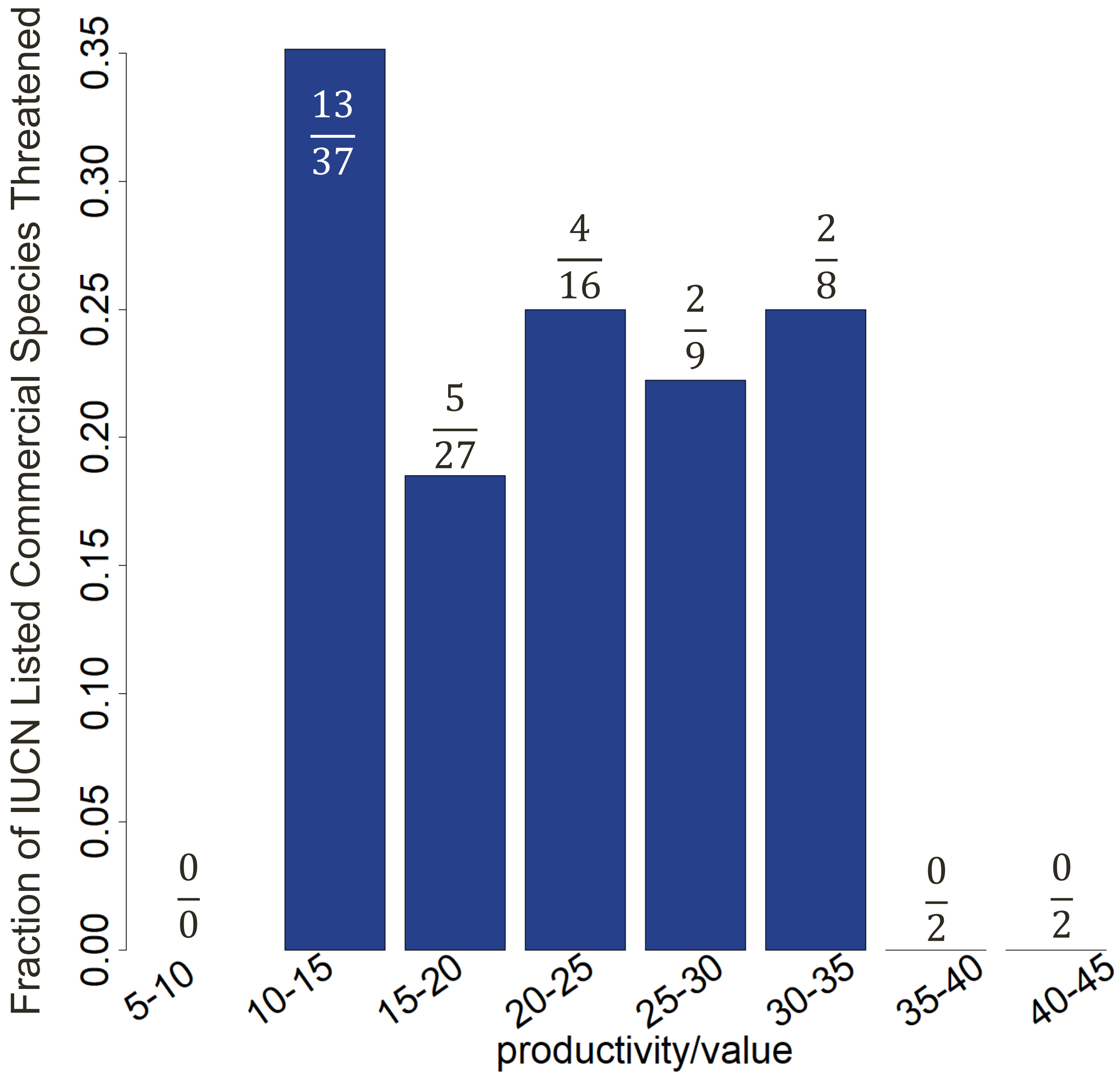
METHODS

- I extracted these data and compiled them in a new data excel sheet, mostly manually copying and pasting. Then the attributes such as region, status, stock list, and value were matched by species.
- Histograms and other plots were created to visualize the data using R. I made many different plots and ran summary statistics, but the focus was on relationships so those are omitted in this poster and presentation.
- During this stage of the project the analysis was limited to assessing general trends and visualization.

RESULTS

Risk Measure 1:

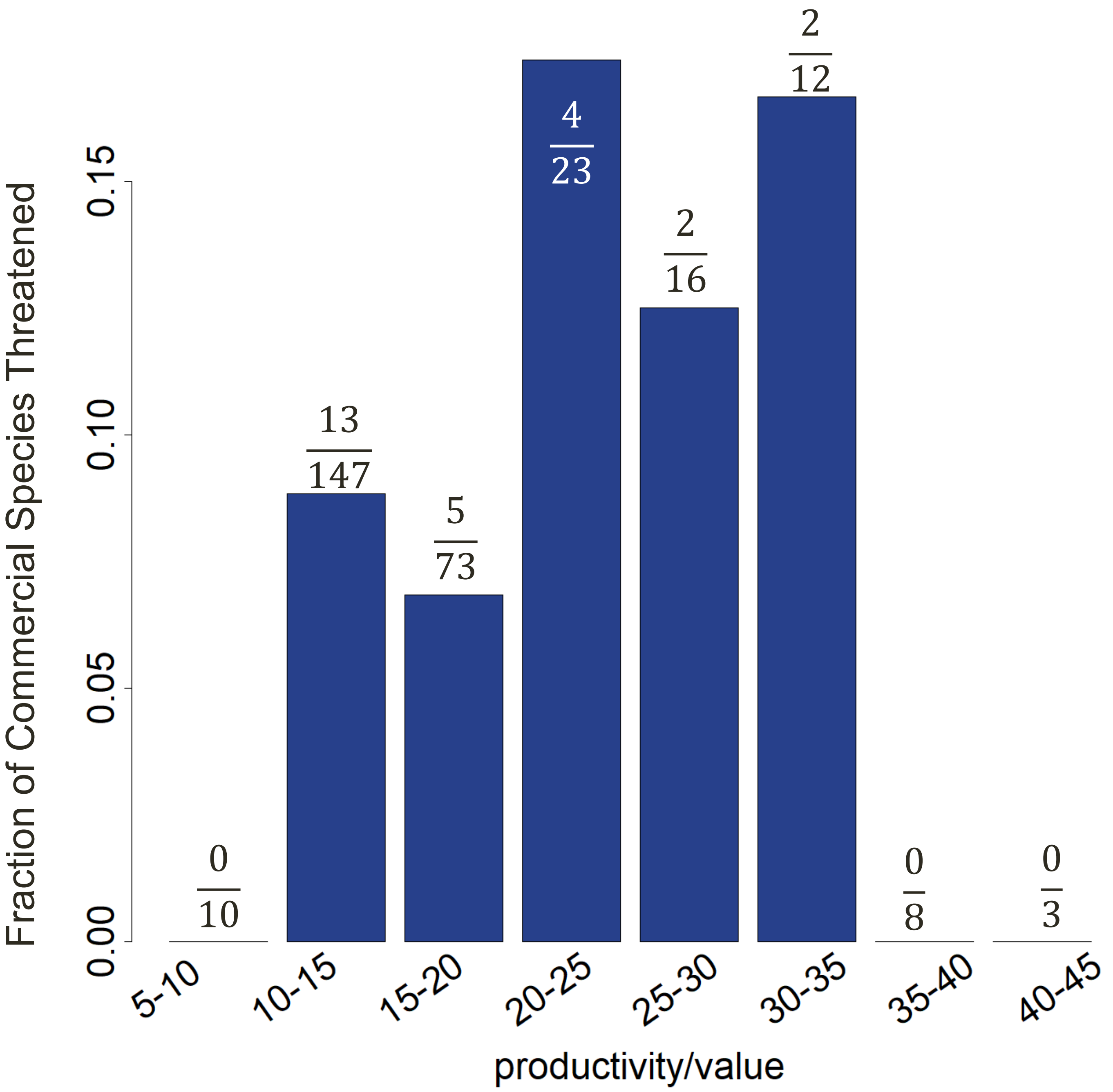
This is the ratio of the most threatened stocks compared to any status. This is meant to show the trends within the IUCN listed stocks. There are a total of 118 listed stocks.



RESULTS

Risk Measure 2:

This is the ratio of the most threatened statuses to all stocks in the dataset used. This is meant to show the trends between most threatened stocks and the larger dataset. There are a total of 628 stocks assessed.



RESULTS

Risk Measure 3:

This is not a ratio, but rather a modified histogram to weight, or emphasize, by threat level. High risk has a high weight whereas low risk has low weight. A stock that had no listed was weighted at zero, not showing up here despite being counted. This was performed on all 628 stocks. The weighting used is listed below.

Extinct=5/5

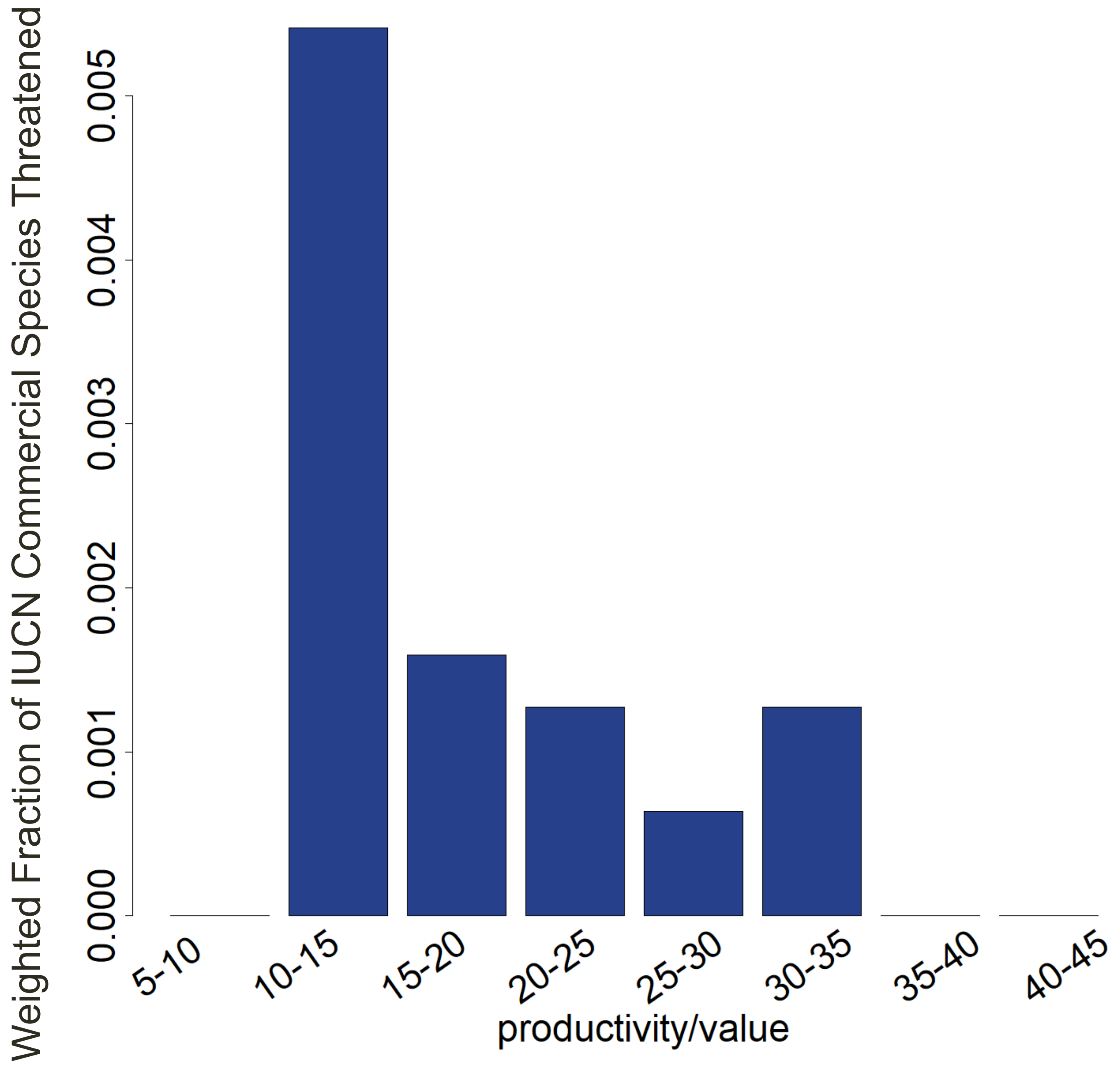
Extinct in Wild=4/5

Critically Endangered=3/5

Endangered=2/5

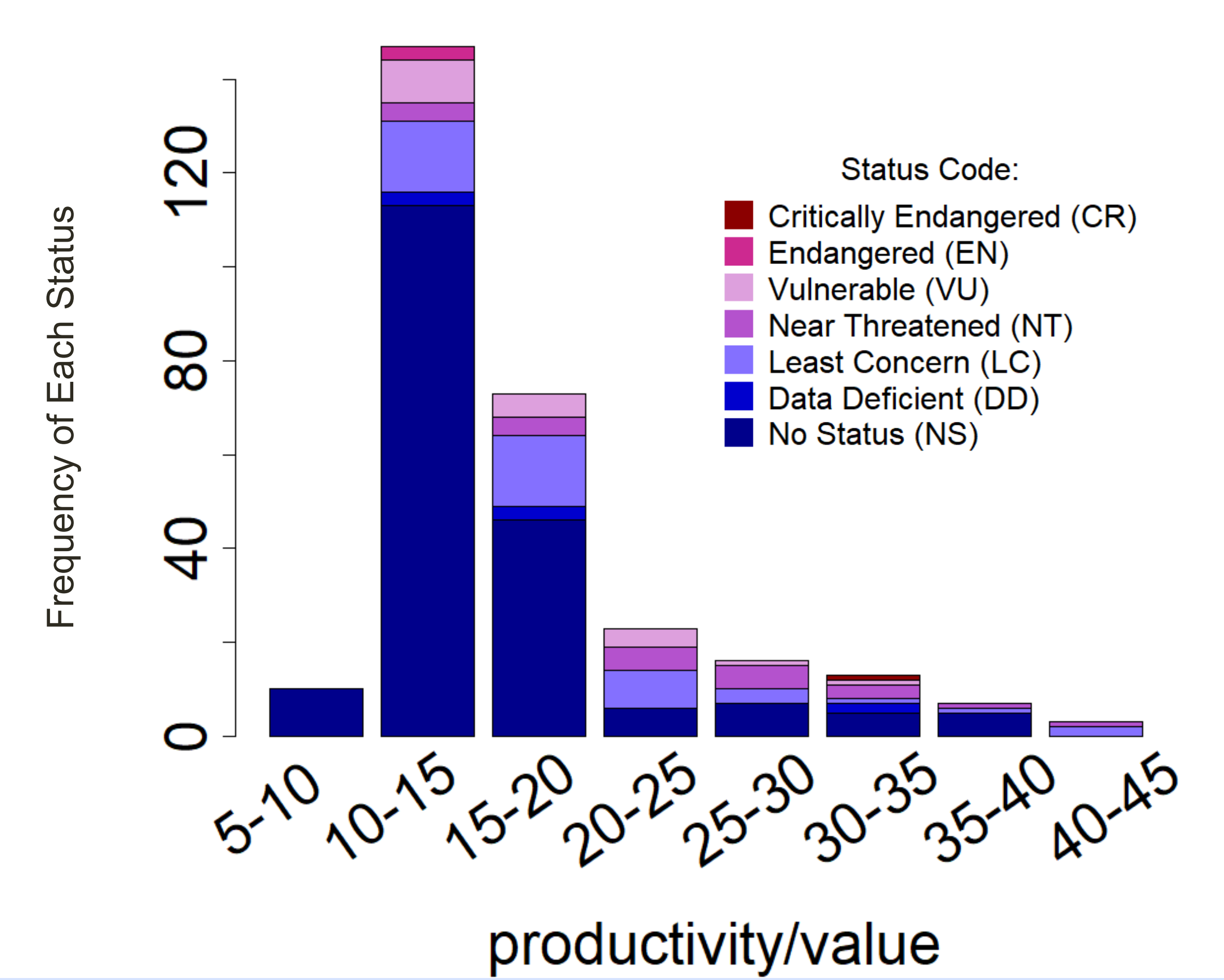
Vulnerable=1/5

Data Deficient and No Status= 0/5



RESULTS

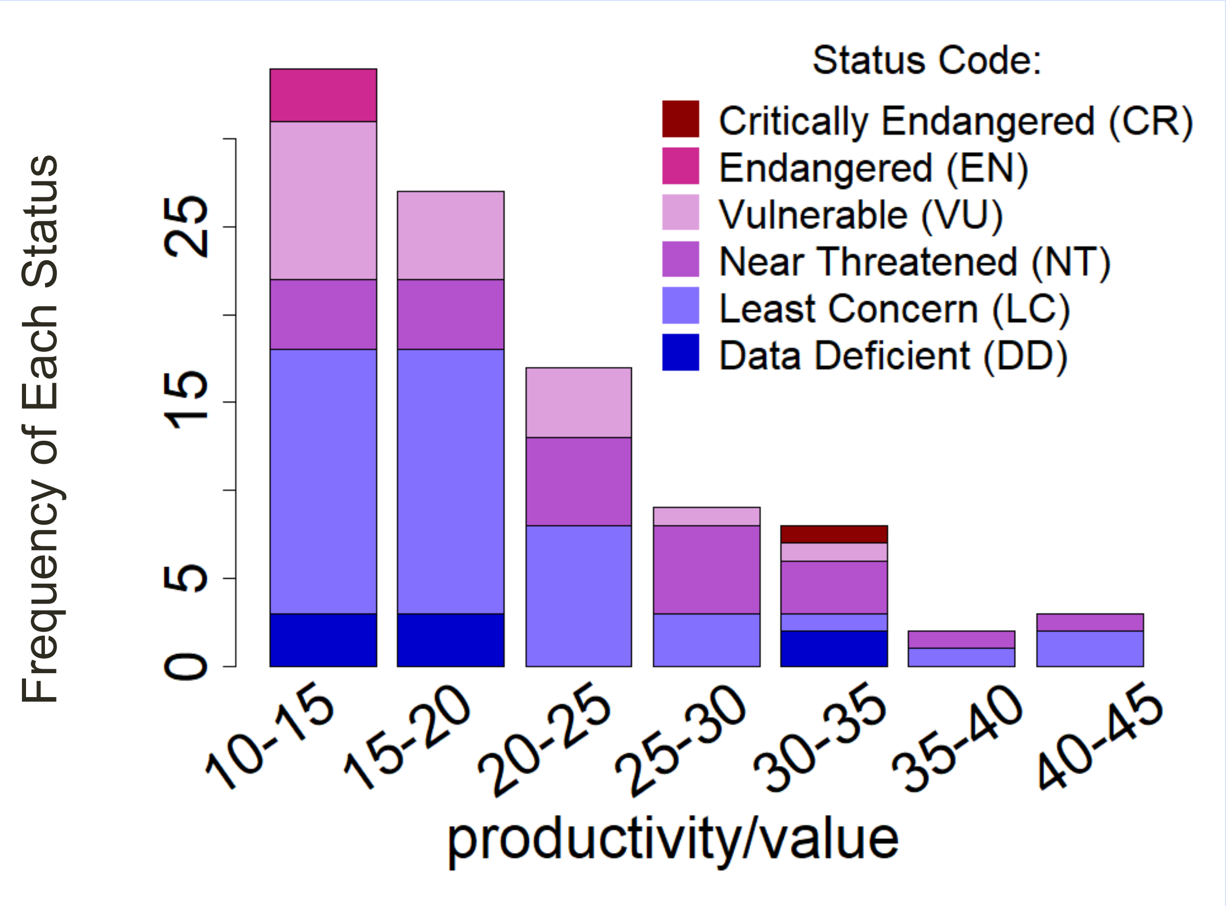
This is a stacked barplot depicting the distribution and frequency of IUCN status across the PI. The majority of species taken from the RAM database did not have an IUCN status, listed in the top graph as "No Status".



RESULTS

The Second plot represents the same dataset but with the “No Status” species removed to better emphasize the distribution of species with known status.

Most species, with or without status, appear to have lower productivity and higher value.



CONCLUSIONS

- One result of this project was the creation of a unique database combining economic and ecological data as well as extinction risk.
- Based on the results from the plots created, it appears that species at the far ends of the productivity/value spectrum may face similar extinction risk. These species would have very different economic and ecological characteristics despite similar impacts.
- However, a seen in the three different risk measures used, results vary by method of analysis.
- More work is needed on this project in order to test these relationships.

DISCUSSION

- Most of the limitations of this project relate to the short timespan. Much of my time was spent understanding the data available, determining what was useable, manually compiling it, and learning how to use software for analysis. This limited time spent working on more complex analyses and resulted in potentially incomplete data.
  - The regional data for the stocks was matched to economic data that was organized by country. I subjectively matched the data by grouping countries according to geographic region and proximity to water bodies. If given more time and resources, I would establish a standard means of delineating regions by country, perhaps using GIS and fishing data.
  - Due to manually transferring most of the data before learning how to do it using R and downloading certain data in a complete package, I expect there may be some mismatched or missing values. I will move forward with analysis after using merge tools and commands to match data instead. This will result in more accurate transfers and help keep everything more organized.
  - I also collected the IUCN data from manual searches on their website before learning to download their datasets. Downloading data based on searches and then merging them is the more effective way to get all data for the listed species and populations.

NEXT STEPS

- I am currently continuing research on this project after taking a hiatus to focus on graduating this year.
- Next steps:
  - Recompiling the data using merge tools to integrate it more accurately and effectively.
  - Taking the log of the productivity/value data to see if it could result in smoother histograms with more bins that could clarify trends or show more detail.
  - Running logistic regressions on the data to evaluate the relationship between economic and ecological factors. There has already been some work done on this using the existing dataset, but it will be re-run once data is redone. We may also decide on other means of analysis depending on what comes from taking the log of the data.
  - Looking for other regression tests that may be more descriptive than binomial regressions—potentially multinomial or other.
  - Comparing these results with my advisors to see how it relates to the results of their model on institutional response.

ACKNOWLEDGEMENTS

Many thanks to the Pinsky Lab for hosting me over the summer in New Jersey, Rutgers University, the National Science Foundation, my mentor Dr. Kathryn Sobocinski, RAM Legacy, The International Union for the Conservation of Nature.

REFERENCES

[1]Tekwa, E. W., Fenichel, E. P., Levin, S. A., & Pinsky, M. L. (2019). Path-dependent institutions drive alternative stable states in conservation. *PNAS, 116*(2), 689–694.

[2]Dasgupta, P., Mitra, T., & Sorger, G. (2019). Harvesting the Commons. *Environmental and Resource Economics*, *72*(3), 613–636.

[3]Lam, V. W. Y., Sumaila, U. R., Dyck, A., Pauly, D., & Watson, R. (2011). Construction and first applications of a global cost of fishing database. *ICES Journal of Marine Science*, *68*(9), 1996–2004.

QUESTIONS?

Email me or check out my Github if you have questions, concerns, ideas, or would like to learn more!

nordal.rondi@gmail.com

https://github.com/pinskylab/species-extinction_RN