FISH ARE THE BEST

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1 Abstract

2 Introduction

2.1 The need for conservation efforts

Our planet is currently losing species at such a significant rate that this period has been called the "Sixth mass extinction" (Barnosky et al. 2011). There are many valid reasons as to why this is viewed as a negative thing; these range from losing 'ecosystem services'- i.e. we humans will lose valuable future sources of medicine and food, to the intrinsic value that having biodiverse ecosystems have, which is harder to quantify. True extinction events cannot be reversed (sorry, Jurassic Park), but through conservation action, species that are extinct in the wild can be reintroduced; vulnerable or threatened species can be protected, and entire ecosystems can be protected. Unfortunately, conservation actions are resource intensive and expensive, and we are unable to protect every threatened or vulnerable species on the planet - and this is compounded by the fact that we do not have comprehensive, up-to-date data on which species are threatened globally. Therefore, with the knowledge that we do have, conservationists are forced to select which species to prioritise. There are many metrics by which conservationists evaluate species' worthiness of protection, and the methods through which they can be best conserved. Some metrics focus on a species' "irreplaceabilitiy" (i.e. focus on endemic species); others focus on physiological or genetic 'uniqueness', unusual abilities, or species living in rare habitats (Brooks et al. 2006). The problem with some of these approaches is that they can be skewed towards organisms that are charismatic (i.e. the Giant Panda), and miss species that are visually unremarkable or belonging to a non-charismatic taxa, yet that that may be the sole survivor of millions of years of evolutionary history (Taylor 2002). There is significant taxonomic and geographic bias reported in conservation research (Taylor 2002; Darwall et al. 2011; Watson et al. 2017), which highlights the clear need for a method that is avoids taxonomic bias, and can be applied widely to identify which species which require conservation prioritisation.

The 'EDGE' metric seeks to solve this problem of biased prioritisation by calculating prioritisation lists of species using the evolutionary history represented by species - it's "Evolutionary Distinct" (ED) score combined with its level of global endangeredness (GE). A species' ED score is calculated using a phylogenetic tree, and the score represents the numbers of millions of years of evolutionary history that is within that species (Isaac et al. 2007). Species that have speciated recently, or that have many recent 'cousin' species will have lower ED scores than species that have no close living relatives, and that speciated a long time ago.

The GE score of a species is calculated using the IUCN's 'Red List' assessment for that species (Isaac et al. 2007), in which species are categorised according to how stable their populations are and how likely they are to become extinct (IUCN 1975). These categories are shown in Figure **??**. This metric was chosen for this study as it provides a mechanism to comprehensively assess species with family groups (or larger), and this study believes it will produce results that can be used to meaningfully influences the manner in which these species are considered.

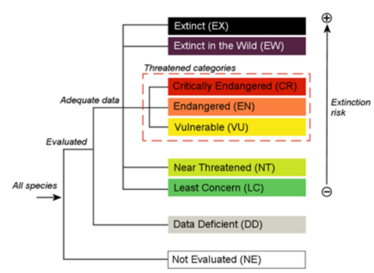

Figure 1: IUCN Red List categories (IUCN 1975)

2.2 Why fish?

The group considered in this study are the *Actinopterygii*, commonly known as the ray-finned fish. Actinopterygii are the largest class of vertebrate, with over 33,000 constituent species, with more species being described regularly (Froese and Pauly n.d.). For context, mammals are thought to have closer to 6,400 extant species (Mammalogists 2020); reptiles have 9,500 species (Pincheira-Donoso et al. 2013) ; and birds have around 18,000 (Barrowclough et al. 2016). Unfortunately, the Actinopterygii are also proportionally the most understudied classes of the vertebrates. for example, just over 50% of Actinopterygii are assessed in the IUCN Red List, compared with the 62-90% of other classes, as laid out in Table **??**.

Class	# of Species	# Assessed	% Assessed
Actinopterygii	33,000	17,955	54.4
Mammalia	6,500	5850	90.0
Aves	18,000	11,147	62.0
Reptilia	9,400	7892	84.0

Table **??**: IUCN Red List assessments for vertebrate classes
(Mammalogists 2020; Pincheira-Donoso et al. 2013)
(Barrowclough et al. 2016; Froese and Pauly n.d.)

The IUCN is not the only research body in which Actinopterygii are poorly represented. A quick search in WebofScience also demonstrates the lack of research into this class. When searching for topics that include the class names of the groups mentioned in Table **??**, the results are as follows: Actinopterygii -2055; Mammalia - 8905; Reptilia - 6,030; Aves - 13,116. This bias is acutely present in conservation science - a recent study by Watson et al. 2017 revealed that, of the vertebrate groups, fish had the highest imbalance between number of published merciless and number of described species (16% and 50% respectively).

Despite the lack of studies into Actinopterygii, many species of fish are acknowledged to be very important as a source of food and employment - through fishing, harvesting activities and tourism and entertainment. Fish consumption has been rising steadily for the past 6 decades, as highlighted clearly in Figure **??**.

Many people, especially in Europe and Northern America, are increasing the amount of fish in their diet - some to improve their health (Rimm 2006)), and others to lessen their impact on the environment (Mary and Shoup 2018). Younger generations are particularly aware of the impact their food choices have on the planet (Mary and Shoup 2018), so it could be assumed that this trend of eating more fish is unlikely to change. This increased demand for fish (and fish-related products) has lead to an increase in aquaculture (farming fish) (Belton, Bush, and Little 2018). Wild-caught fish number are in decline due to stock exhaustion and populating collapse rather than a decrease in interest in wild caught fish (Tremblay-Boyer et al. 2011; Belton, Bush, and Little 2018).

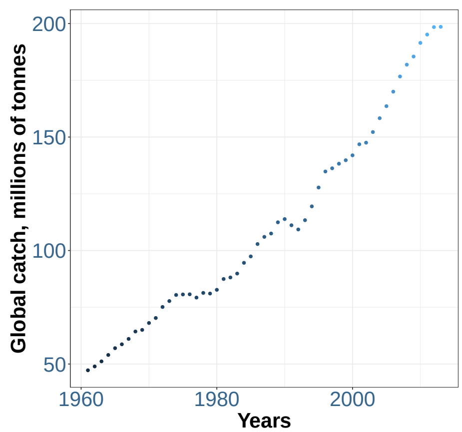

Figure 2: Global catch of freshwater, demersal, pelagic and marine fish, (Department and Aquaculturer 2020)

Marine ecosystems in particular are under increasing pressure from human action. Globally, governments and scientific bodies have agreed that ecosystems need to be protected in order to protect the future of marine resources (Muraki Gottlieb et al. 2018).

Marine Protected Areas (MPAs) are one form of protection - however the definition of these vary significantly from one location to another (Marinesque, Kaplan, and Rodwell 2012). In general, a MPA's success is evaluated by its effectiveness at conserving 'keystone' species, or their value to local fishing activities (Marinesque, Kaplan, and Rodwell 2012). As discussed above, by considering only 'keystone' species, considerable ecosystem damage may occur un-measured, and diverse species may go un-protected.

Given that many species of fish exist in both the marine and freshwater realms, and many more migrate around the globe, clear conservation prioritisation for fish will be crucial to ensure we do not fail to protect vulnerable and non-charismatic species.

2.3 X, Y and Z

subsection: why these fish in particular

[now to sum everything up]

It is clear that the Actinopterygii group is both under-studied and under-protected, despite their importance to human populations across the globe. This study is a first step in directly addressing this imbalance. Using the EDGE metric, we create conservation prioritisation lists for [X, Y and Z] and, along with geospatial analysis of their current habitats and threats, highlight methods through which vulnerable species could be protected. This study also provides a roadmap that will be useful for the creation of reports regarding other family groups within the Actiopterygii class.

3 Methods

4 Results

5 Discussion

References

Barnosky, Anthony D. et al. (2011). "Has the Earth's sixth mass extinction already arrived?" In: *Nature* 471.7336, pp. 51–57. ISSN: 00280836. DOI: `10.1038/nature09678`.

Barrowclough, George F. et al. (2016). "How many kinds of birds are there and why does it matter?" In: *PLoS ONE* 11.11, pp. 1–15. ISSN: 19326203. DOI: `10.1371/journal.pone.0166307`.

Belton, Ben, Simon R. Bush, and David C. Little (2018). "Not just for the wealthy: Rethinking farmed fish consumption in the Global South". In: *Global Food Security* 16.October 2017, pp. 85–92. ISSN: 22119124. DOI: `10.1016/j.gfs.2017.10.005`. URL: `https://doi.org/10.1016/j.gfs.2017.10.005`.

Brooks, T. M. et al. (2006). "Global biodiversity conservation priorities". In: *Science* 313.5783, pp. 58–61. ISSN: 00368075. DOI: `10.1126/science.1127609`.

Darwall, William R.T. et al. (2011). "Implications of bias in conservation research and investment for freshwater species". In: *Conservation Letters* 4.6, pp. 474–482. ISSN: 1755263X. DOI: `10.1111/j.1755-263X.2011.00202.x`.

Department, Fisheries and Aquaculturer (2020). *Fisheries and Aquaculture Department*. URL: `http://www.fao.org/fishery/` (visited on 03/23/2020).

Froese, R and D Pauly (n.d.). *FishBase*. URL: `www.fishbase.org,%20version%20(12/2019).`.

Isaac, Nick J.B. et al. (2007). "Mammals on the EDGE: Conservation priorities based on threat and phylogeny". In: *PLoS ONE* 2.3. ISSN: 19326203. DOI: 10.1371/journal.pone.0000296.

IUCN (1975). *IUCN RED LIST CATEGORIES AND CRITERIA*. Tech. rep., 59P.

Mammalogists, American Society of (2020). *Mammal Diversity Database*. URL: www.mammaldiversity.org. (visited on 2020).

Marinesque, Sophie, David M. Kaplan, and Lynda D. Rodwell (2012). "Global implementation of marine protected areas: Is the developing world being left behind?" In: *Marine Policy* 36.3, pp. 727–737. ISSN: 0308597X. DOI: 10.1016/j.marpol.2011.10.010. URL: http://dx.doi.org/10.1016/j.marpol.2011.10.010.

Mary, By and Ellen Shoup (Oct. 2018). "Cargill : Americans are eating more fish than they did five years ago , prioritizing nutrition and sustainability". In: *Food Nativator USA*. URL: https://www.foodnavigator-usa.com/Article/2018/10/02/Cargill-Americans-are-eating-more-fish-than-they-did-five-years-ago-prioritizing-nutrition-and-sustainability.

Muraki Gottlieb, Hiroko et al. (2018). "Area Based Management Tools , Including Marine Protected Areas in Areas Beyond National Jurisdictionn, 9 – 11 October 2018 at IUCN Headquarters, Gland, Switzerland. Gland, Switzerland: IUCN." In: October, pp. 1–16. URL: https://www.iucn.org/sites/dev/files/content/documents/iucn%7B%5C_%7Doct2018%7B%5C_%7Dabmt%7B%5C_%7Din%7B%5C_%7Dabnj%7B%5C_%7Dworkshop%7B%5C_%7Dreport%7B%5C_%7Dcorr.pdf.

Pincheira-Donoso, Daniel et al. (2013). "Global Taxonomic Diversity of Living Reptiles". In: *PLoS ONE* 8.3, pp. 1–10. ISSN: 19326203. DOI: 10.1371/journal.pone.0059741.

Rimm, Eric B (2006). "Fish Intake, Contaminants, and Human Health". In: 296.15, pp. 1885–1900.

Taylor, Raymond L. (2002). "Taxanomic Bias in Conservation Research". In: *Science* 297.10, pp. 191–192. ISSN: 19457197. DOI: 10.1210/jcem-10-10-1361. URL: https://www.jstor.org/stable/3077032.

Tremblay-Boyer, Laura et al. (2011). "Modelling the effects of fishing on the biomass of the world's oceans from 1950 to 2006". In: *Marine Ecology Progress Series* 442, pp. 169–185. ISSN: 01718630. DOI: 10.3354/meps09375.

Watson, James E.M. et al. (2017). "Changing trends and persisting biases in three decades of conservation science". In: *Global Ecology and Conservation* 10, pp. 32–42. ISSN: 23519894. DOI: 10.1016/j.gecco.2017.01.008. URL: http://dx.doi.org/10.1016/j.gecco.2017.01.008.

6 Appendix 1: Figures