# Analytical reference points for data-limited Carcharhinid sharks

## Introduction

* Why care about sharks/reef sharks?
  + Sharks are being overexploited on a global level (Worm et al., 2013)
  + Shark fisheries have long been important at local, regional, and international scales from social, cultural, and economic perspectives. (Dulvy et al., 2017)
  + “The last decade has seen growing global concern about the status of elasmobranch populations, particularly due to their intrinsic sensitivity to fishing impacts and their very low population growth rates (Dulvy et al. 2014)”.
  + Inherently more vulnerable to fishing than other kinds of fishes
  + Reef shark populations are collapsing, because of illegal fishing, because rarely subject to specific limits on fishing pressure (Robbins et al., 2006)
  + coastal shark populations in the Atlantic have declined by as much as 85% in the past two decades (Camhi, 1999; Baum et al., 2003).
  + Loss of apex predators on reefs may result on damaging trophic cascades (Bascompte et al., 2005)
  + Reef sharks therefore merit greater research attention to underpin science-based management and conservation action
* Why are sharks hard to assess/study?
  + chondrichthyan fishes are a particularly data limited group (Barker & Schuessel 2005.. others), which explains why most stocks worldwide have not been assessed with formal fisheries stock assessment methods (Cortés et al., 2012)
  + ‘Stock assessments take money and expertise (Geromont and Butterworth, 2015) which developing countries usually cannot afford’ (Evans, 2000) better reference for this?
* Why use age-structured catch-free analytical methods to find sustainability reference points?
  + ‘In fisheries where there is a high degree of uncertainty in reported catches, or catches are not reported at all, stock assessment models that rely on catch data may not be appropriate. For numerous shark species there is uncertainty about the magnitude of commercial and recreational catches, in part due to identification problems’ (Cortés et al., 2006)
  + Fishery-dependent data can be unreliable for sharks, as they are hard to identify and are often not the target species (Baum et al., 2003; Burgess et al., 2005; Clarke and Hoyle, 2014; Harry et al., 2016)
  + estimation of reference points is a key step in determining stock status (Clarke and Hoyle, 2014; Cortés and Brooks, 2018) other source?
  + The population growth rate of many shark species has been overestimated in the past because of the assumption that all juveniles survive to maturity (Pardo et al., 2016). Using age-structured survivorship data addresses that problem
* Why use life history traits to find reference points?
  + Life history traits related to body size, growth, age and reproduction are known to be correlated with each other (Cortés, 2000; Hutchings et al., 2012) and thus may be use to predict related parameters such as rate of intrinsic increase or lifetime reproductive output (Frisk et al., 2011; Jennings et al., 1998; Reynolds et al., 2005)
  + ‘the most fundamental parameter in population biology is the reproductive rate at low population size (ã)’. … It is ‘central to calculating r (population growth), reference points, and estimation of long term anthropogenic impacts (Myers et al., 1999)
  + Body size and age at maturity can be used to predict Rmax (Hutchings et al., 2012)
* Why use modelling to predict unknown life history traits ?
  + Life history traits, while more commonly available than catch data, are still not available for many of the more obscure species which are for example, of less commercial interest or occur in lower-income countries
  + Shark stock assessments often borrow data from similar species/use species complexes because there is not enough species-specific data available (NMFS, 2006)
* In this paper…
  + I will do this this and this analysis, producing these results
  + I will focus on a group of species which are understudied, even in the shark world, but nevertheless urgently require science-based management and conservation action
  + Risk Assessment methods (such as estimating reference points with life history data) for elasmobranchs has lagged behind that of other vertebrate groups (Cortés et al., 2015), therefore this paper fills a hole in the literature
  + Sustainable shark fishing is feasible with the right scientific underpinning (Simpfendorfer and Dulvy, 2017) so we should strive to achieve that end…this paper contributes…

## Methods

* Add notes from Ch3 Notes

Part 1: Data Collection

Part 2: Model fecundity, mortality and maturity parameters

* It’s ok to calculate parameters you don’t have based on known relationship to parameters you do have, based on previous empirical work (Kacev et al., 2017)
* Previous studies have also used data from better-studied species to model life history parameters of data-poor shark species (Jiao et al., 2011) robin hood approach (Kacev et al., 2017)
* Bayesian hierarchical methods are great for data-poor species bc they allow you to borrow strength from species with good-quality data (Jiao et al., 2011)

Part 3: Calculate alpha-hat and then limit and target reference points for each species

* SPR level is a common proxy for MSY reference points (Brooks et al., 2010)
* ‘Analytical reference points relative to unfished biomass can be calculated using only the maximum lifetime reproductive rate, and the slope at the origin of the stock-recruitment curve. These 2 parameters can be calculated in turn using maturity at age (ma), fecundity at age (pa, the number of offspring produced per breeding female per year), and natural mortality at age (Mj)’. While this method relies only on fishery independent data and can be used in the absence of a full stock assessment, it still gives a reliable determination of stock status 94% of the time (Brooks et al., 2010; Cortés and Brooks, 2018).

## Results

* 3 charts showing effect size of predictors on mortality, fecundity and maturity (from part 2)
* Table with each species and values of parameters going into alpha hat (S0, theta, etc), and Blim and Btarget
* Chart showing target and limit reference points for each species – talk about relative resilience to fishing of different species

Discussion

References

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Figures

Tables