CARMMHA EE: Population Biology - Evidence Dossier
Workshop: 13th & 14th Jan 2020, SWFSC - La Jolla, CA.

Introduction

Typically, an expert elicitation is informed by an Evidence Dossier, which the experts can review in advance. The main purpose of the dossier is to ensure that all relevant information is assembled and is available to all the experts during elicitation to aid the experts in making judgements. Experts have been briefed using a pre-webinar on the scope and approach to this elicitation.

This dossier summarises information from other sources, each of which has a dedicated link to the source.

This expert elicitation serves to update two models.

- An age-structured model for Bay, Sound and Estuary (BSE) bottlenose dolphins (BND) - detailed in the Schwacke et al 2019 paper and Supplementary Information.
- A stage-structured model for all other cetacean species in the Gulf of Mexico - described in MMIQT -NRDA and summarised here.

Quantities of Interest:

Below are the desired list of quantities of interest for which we would like to carry out expert elicitation exercises. We recognise this is more than can be achieved in a single workshop, but the list below reflects the priorities and thus the order in which we'll elicit.

1. Shape of density dependence fecundity response (DDFR)(defined by the Rho parameter (see Figure 2 and associated text in Schwacke et al 2019 - below)) for the:
    a. BSE bottlenose dolphins (age-structured model).
    b. all other GoMex cetacean species (stage-structured model).
2. Baseline demographic parameters for other Gulf of Mexico cetaceans (e.g. sperm whale).
    a. Age at 1st reproduction, interbirth interval (IBI), calf survival, juvenile survival, adult survival.

Background

Cetaceans in the Gulf of Mexico (GOMx)

"There are [...]21 cetaceans species (in the Gulf of Mexico). [...] Cetaceans have adapted to a wide variety of habitats in the marine environment and can be found throughout the northern Gulf of Mexico (Rosel & Mullin 2015)(from PDARP Chapter 4) (see Species Table at end of

this dossier). "*In the GOMx, accounts of Bottlenose Dolphins, mostly from stranded animals, suggest the presence of both offshore and coastal ecotypes (Gunter 1942, Shane et al. 1982, Würsig et al. 2000), and current classification of T. truncatus in the GOMx includes both the offshore and coastal ecotypes based on genetic analyses, with the coastal ecotype found in BSE, coastal, and shelf waters and the offshore ecotype confined primarily to deeper waters of the continental shelf and slope (Curry 1997, Vollmer 2011, Waring et al. 2013). Furthermore, research based on skull morphology suggests that the offshore ecotype is larger than the coastal ecotype (Turner and Worthy 2003).*" (*from* Vollmer & Rosel, 2013).

Density dependent response

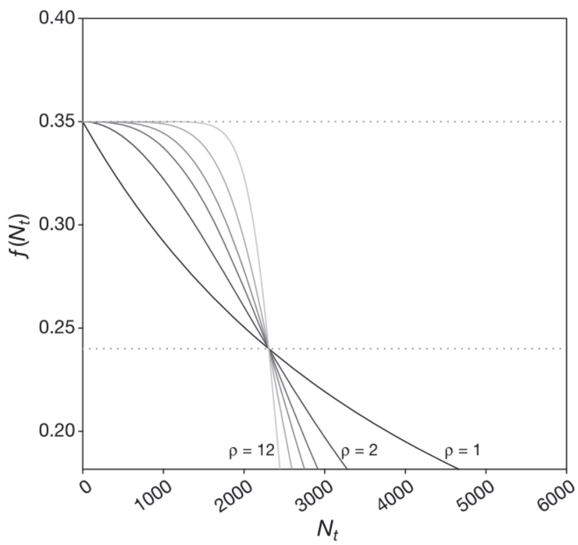

Fig. 2. Fecundity rate, $f(N_t)$, as a function of bottlenose dolphin *Tursiops truncatus* population size, N_t. Solid curves demonstrate the generalized Beverton-Holt function with $N_{nominal} = 2306$, $F_{nominal} = 0.24$, and $F_{max} = 0.34$, and varying values of the shape parameter, ρ = 1, 2, 3, 4, 6, and 12. Dotted horizontal gray lines indicate F_{max} and $F_{nominal}$ values

Fowler 1981a notes that evidence for any kind of density dependent response (DDR) available from at least 16 marine mammal species (9 of which are cetaceans)(see Table 1 and 2) and that resource levels are typically the primary cause (though some species have social factors that might also affect DDFR).

In terms of the possible shape of DDR, they highlight this is very unlikely to be linear and that that all such "large mammal" populations tend to exhibit greatest rate of population change at population levels close to "mean naturally occurring population levels (or carrying capacity K)" at >50% of K. They examine the ratio of max. net productivity level to carrying capacity (R = MNPL/K) and Figure 3 of that paper is below (and shows values of R relative to rate of increase per generation time) - which gives a guide at which point DDR might occur. They also use this to estimate Stenella populations might have R=0.81 and Dall's porpoise might have R=0.65 (N.B. re-analysis of these data call into question the validity of these calculations (noted in Taylor and Demaster 1993)). In broad terms they note that "*species with low maximal rates of increase per generation time exhibit most DDR high at [...] high R*" (and vice versa).

Taylor and Demaster (1993) explore the range of R values (referred to as MNPL/K) possible for marine mammal populations. Summarising other studies they note "*DDR are not abrupt (knife-edge)*" (later related to values of R>0.85) and that "*DDR have not been shown to be concave (higher rates of change at low density).*" - though theoretical arguments have been made that concave DDR could occur spatial environmental variation in considered. Kasuya 1991 suggests that DDR may occur at R>90% (though this was determined via assessments male body size - females showed no change in DDR in body size).

Wade 1998 notes: "*For marine mammals, this level is thought to be between 50% and 85% of carrying capacity and is more likely to be in the lower portion of that range (Taylor and DeMaster 1993). Therefore, populations are considered depleted by the U.S. Government if they are directly estimated to be below their MNPL, or if they are estimated to be below 50%-70% of a historic population size which is thought to represent carrying capacity (Gerrodette and DeMaster 1990).*"

Fowler, 1981b summarises density dependence relative to life history strategy across a range of taxa. Marine mammals and terrestrial mammals populations are expected to express DDR in the same way (Fowler 1981a, Williams et al 2013). Table 1 and Figure 4 (below) from that paper give an overview of potential shapes relating to survival and fecundity across taxa. See Fredin 1981 for more DDR shapes in terrestrial mammals.

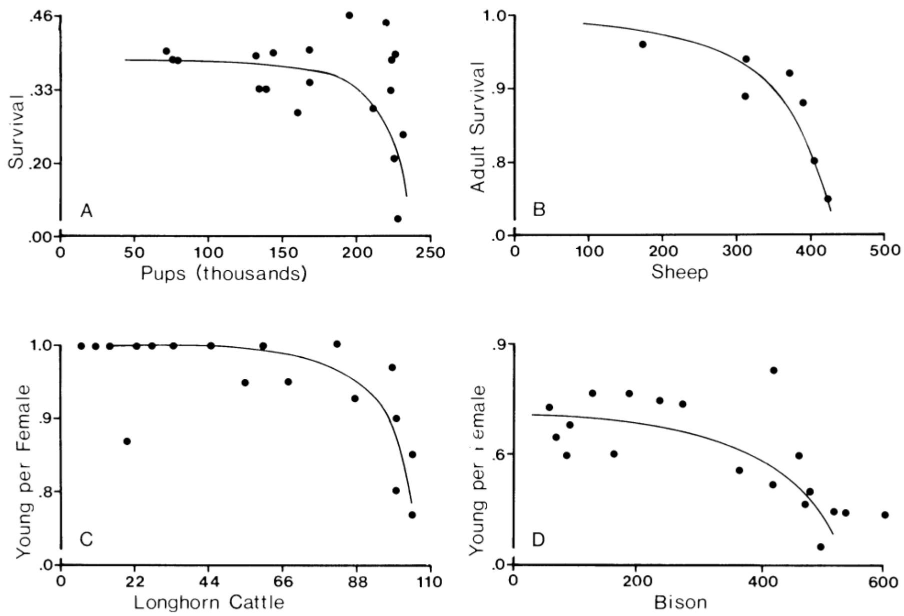

FIG. 4. Examples of nonlinear density-dependent changes in large mammal populations. A: the survival of northern fur seal (*Callorhinus ursinus*) pups as related to the number of pups born (Eberhardt, *in press*). B: The survival of adult Soay sheep (*Ovis aries*) as related to the population size found by Grubb (1974). C: The birth rate of feral longhorn cattle (*Bos taurus*) as related to density as reported by Gross et al. (1973). D: The birth rate of bison (*Bison bison*) as related to population size as reported by Gross et al. (1973).

The paper also outlines possible factors that might change the shape of the DDFR: competition, social organisation of animals in the population, genetic composition, spatial distributions.

Of course, it is also possible that density dependent responses may not be observed in a monitored population. This could be due to additional newborn mortality, and declining proportion of immatures in the population as observed in belugas - Mosnier, et al, in press - or other source of mortality/reproductive failure (and causes are poorly understood (see Wade, et al 2007)). In the beluga whale study a reduction in IBI was observed - moving from a 3 year cycle to a 2 year cycle (possibly indicating some DDR occurred) - but the population stayed at a reduced population size following the decline in population size (as observed in Wade et al 2007).

Baseline Demographic Parameters

As part of the development of the stage-structured model, a comprehensive review of demographic parameters for all GOMx cetacean species. We have provided the sperm whale sheet here, as that is the likely focus of the latter part of the workshop. The purple shaded cells indicate some of the parameters we will discuss. If we move on to other species, more information can be shared. The GOMx sperm whale demography analysis (from matrix models) paper is available here - Chiquet,et al 2013.

GOMx Cetacean Species

Common Name/Species	**Specific Name**
Atlantic spotted dolphin	*Stenella frontalis*
Blainville's beaked whale	*Mesoplodon densirostris*
Bryde's whale	*Balaenoptera edeni*
Clymene dolphin	*Stenella clymene*
Common bottlenose dolphin	*Tursiops truncatus*
Cuvier's beaked whale	*Ziphius cavirostris*
Dwarf sperm whale	*Kogia sima*
False killer whale	*Pseudorca crassidens*
Fraser's dolphin	*Lagenodelphis hosei*
Gervais' beaked whale	*Mesoplodon europaeus*
Killer whale	*Orcinus orca*
Melon-headed whale	*Peponocephala electra*
Pantropical spotted dolphin	*Stenella attenuata*
Pilot whale (short-finned)	*Globicephala macrorhynchus*
Pygmy killer whale	*Feresa attenuata*
Pygmy sperm whale	*Kogia breviceps*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Sperm whale	*Physeter macrocephalus*
Spinner dolphin	*Stenella longirostris*
Striped dolphin	*Stenella coeruleoalba*