How much human-caused mortality might a bird population be able to sustain?

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References

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Thanks to...

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Summary

- Human-caused mortality (e.g. harvest, fisheries-bycatch, power lines)
- How much might be sustainable?
- Wade 1998 - calculate potential biological removal (PBR)

    Conservative estimate of population size (N_{min})

    Maximum (annual) recruitment rate (R_{max})

    Population status

- Niel and Lebreton 2005

    R_{max} predicted from adult survival (s) and age at first breeding (α)

    Simple approximation seems to work well for bird species

- Examples: magpie goose and white-chinned petrel (long-lived)
- Sensitivity of PBR to estimates used

Human-caused mortality

- Fisheries bycatch of seabirds in New Zealand
  - Bycatch uncertain (known to an order-of-magnitude?)
  - Limited demographic information for many species
  - Population size (breeders only?)
  - Adult survival, age at first breeding (fecundity, juvenile survival)
- Marine mammals in USA
  - Wade (1998): rule for potential biological removal (PBR)
  - Simple and yet allows for
    - Density dependence
    - Environmental stochasticity
    - Bias in estimation of population size

Wade's rule

- Conservative estimate of population size (N_{min})
- Maximum recruitment rate (R_{max})
- Recovery factor (f)

$$PBR = 0.5 \times R_{max} \times N_{min} \times f$$

- Objectives

  Maximum net productivity level

  Time to recovery for depleted populations
- Developed through extensive simulation
- Milner-Gulland and Akçakaya (2001)

  PBR works well compared to other rules

Wade's rule

- Conservative estimate of population size (N_{min})
- Maximum recruitment rate ($R_{max} = \lambda_{max} - 1$)
- Recovery factor (f)

$$PBR = 0.5 \times R_{max} \times N_{min} \times f$$

- N_{min} estimated as lower 60% confidence limit
- f between 0.1 and 1, depending on population status
- Allows decision making with minimal information
- Helps focus research effort on populations with clear need

Estimating R_{max} for birds

- Niel-Lebreton formulae

$$R_{max} = \lambda_{max} - 1$$

$$\log(\lambda_{max}) = 1/T_{opt}$$

$$T_{opt} = \alpha + s/(\lambda_{max} - s)$$

- T_{opt} is the generation time under optimal conditions
- Key ideas:

  Both λ_{max} and T_{opt} are related to body mass

  So $(\lambda_{max})^{T_{opt}}$ constant? They found $(\lambda_{max})^{T_{opt}} \sim 3$

- Agrees well with population model for range of species

Estimating R_{max} for birds

- Niel-Lebreton formulae

$$R_{max} = \lambda_{max} - 1$$

$$\log(\lambda_{max}) = 1/T_{opt}$$

$$T_{opt} = \alpha + s/(\lambda_{max} - s)$$

- Niel and Lebreton (2005) apply Wade's rule

$$PBR = 0.5 \times R_{max} \times N_{min} \times f$$

- We consider uncertainty from using estimates of α and s

Selecting f

$$PBR = 0.5 \times R_{max} \times N_{min} \times f$$

f=0.1 minimal increase in recovery time for a depleted population
maintain population close to carrying capacity
minimise extinction risk for population with limited range
threatened or endangered species

f=0.5 recommended by Wade for most healthy populations
protects against bias in estimates

f=1 keep growing population above max. net productivity level

Lower f obviously leads to lower PBR

Estimating N_{min}

$$PBR = 0.5 \times R_{max} \times N_{min} \times f$$

- Conservative estimate of population size
- Wade suggested lower 60% confidence limit
- Possible bias in SE of estimate of N (or unknown)?

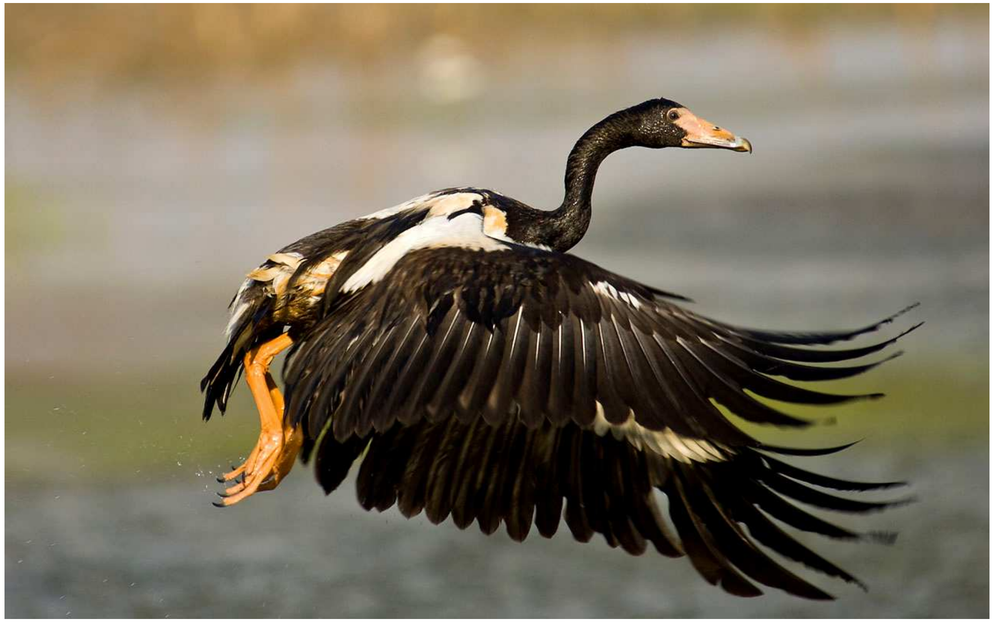
Greater uncertainty in estimate of N leads to lower PBR

Incentive to obtain better data

Magpie goose (*Anseranas semipalmata*)

- Waterfowl in tropical northern Australia
- Estimate of N = 3.5 million (at least 2 million)
- Between 130,000 and 360,000 harvested annually

Indigenous	100,000 to 290,000
Recreational	30,000 to 70,000



Magpie goose (*Anseranas semipalmata*)

α = 2 to 3 years

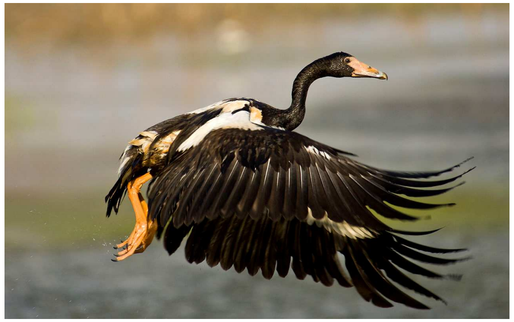
s = 0.85 to 0.95

So R_{max} between 0.13 and 0.29

N_{min} = 2.8 million (assumes lower bound is lower 95% CLimit)

f = 0.5

Harvest between 3% and 6%



- Current rate between 4% and 10%
- Results similar to a published model-based analysis
- Might have suggested need for more detailed analysis

White-chinned petrel (*Procellaria aequinoctialis*)

2.5 million breeding pairs

7 million in total

Vulnerable and commonly caught in fisheries

White-chinned petrel (*Procellaria aequinoctialis*)

α = 6.5 years

s = 0.93

So R_{max} = 0.08

N_{min} = 4.6 million (assumes CV of estimate is 0.5)

f = 0.1

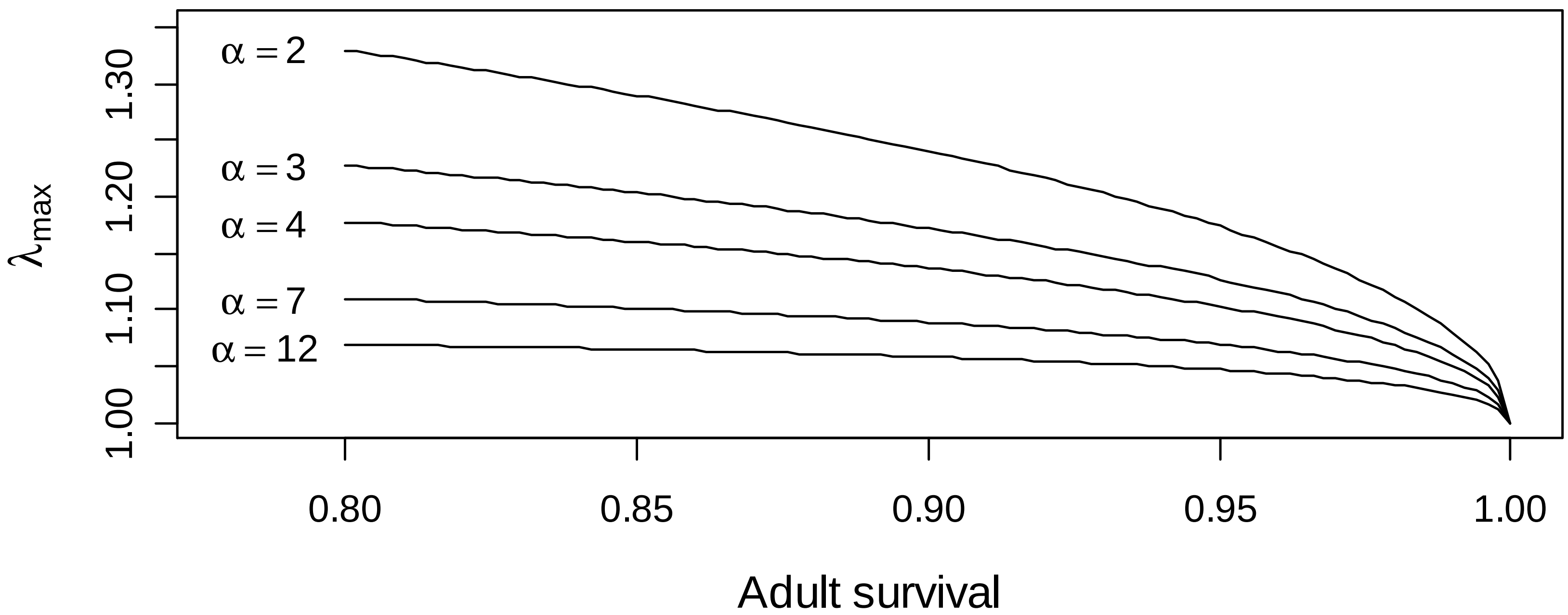
Human-caused mortality should be less than 0.3%

Estimates from one 1990s fishery much higher

Allow for gender/age bias in bycatch?

Bycatch estimates have problems (e.g. misidentification)

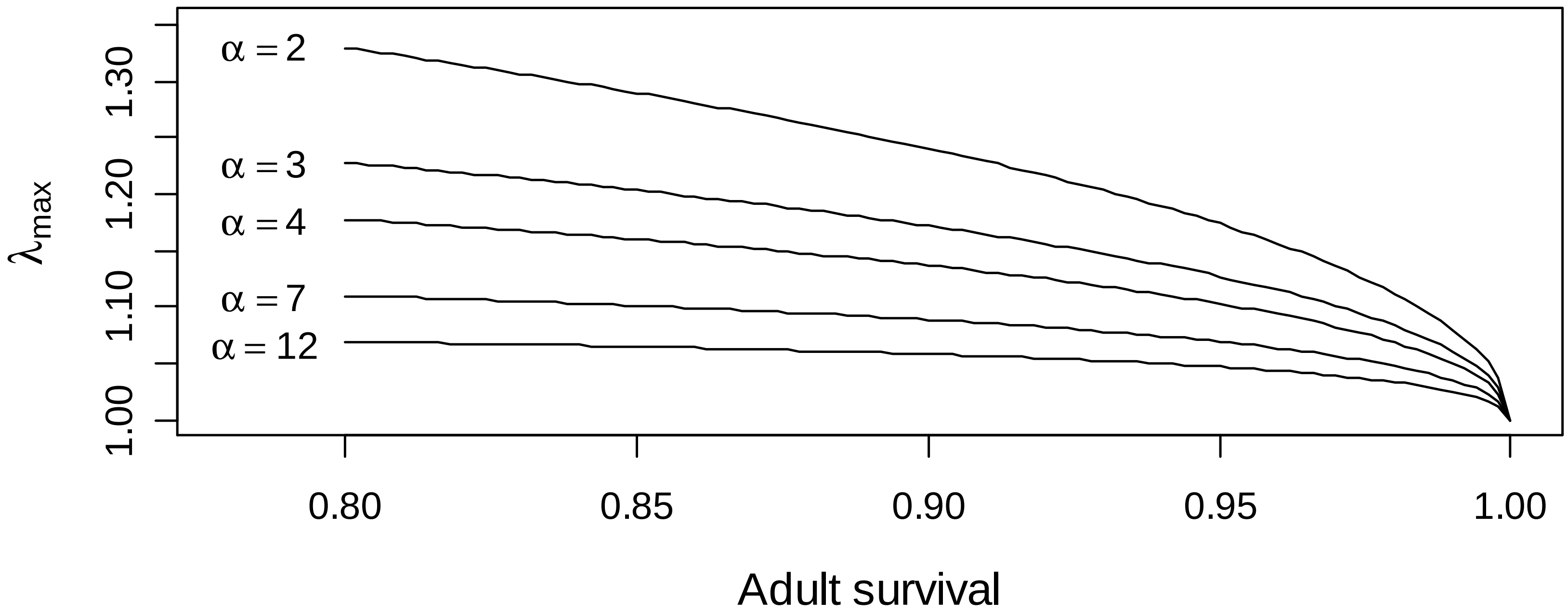
Sensitivity of PBR to α



Higher α gives lower R_{max} (matches intuition)

Reliable estimate of α most important if α low (especially if s low)

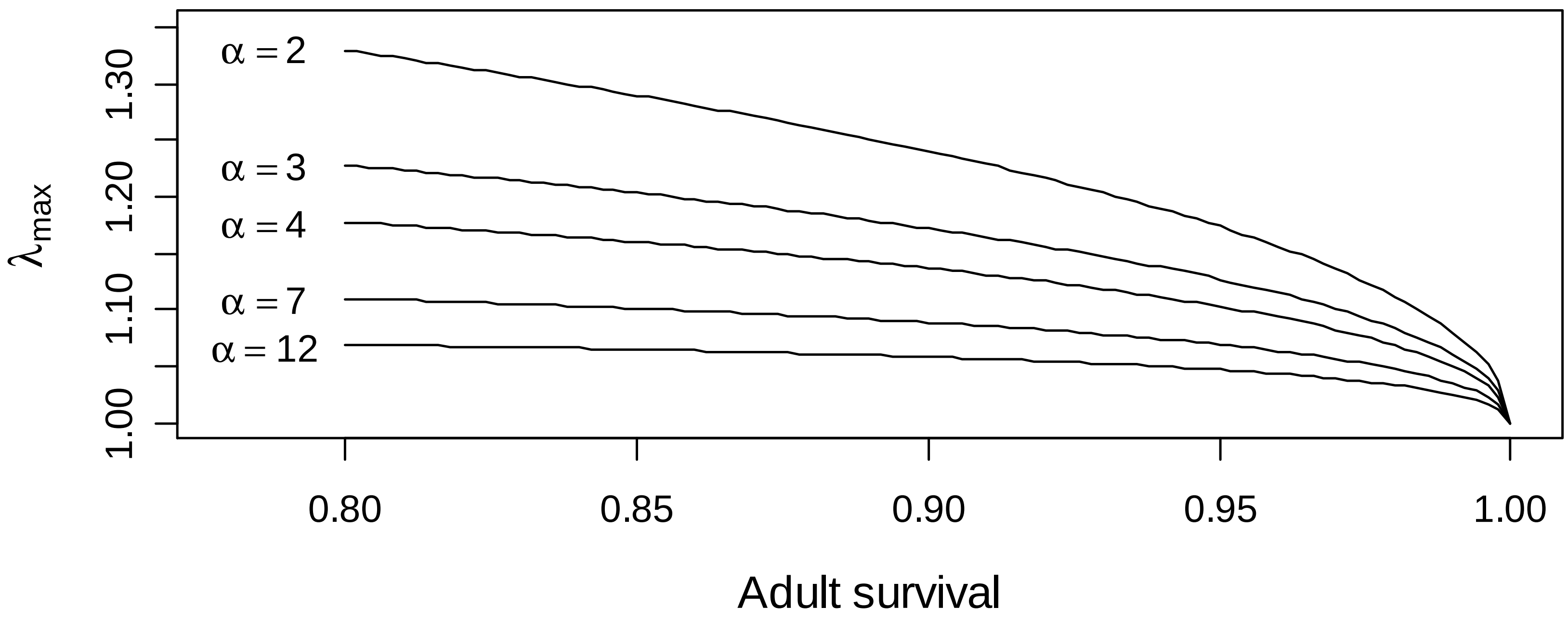
Sensitivity of PBR to s



Higher s gives lower R_{max} (counterintuitive)

Higher adult survival implies lower fecundity

Sensitivity of PBR to α and s



Age at first breeding overestimated (unless mark-recapture used)?

Adult survival underestimated (even using mark-recapture)?

Estimates from non-optimal conditions?

These effects all lead to lower R_{max} (and so lower PBR)

Summary

- How much human-caused mortality might be sustainable?
- Wade 1998 - calculate potential biological removal (PBR)
- Niel and Lebreton 2005 formulae for R_{max} for birds
- No need for direct information on fecundity and juvenile survival
- Possible biases in α and s lead to more conservative PBR
- Emphasis so far on long-lived species - will it work for others?
- Estimation of N_{min} from estimate of number of breeding pairs?
- Estimation of α and s using information from other species?
- Generic population models possible?
- Effect of ignoring immigration?

How much human-caused mortality can a bird population sustain?

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