Seabird Ecology & Conservation (MARS4040) Quiz #3: adaptations / ecomorphology/ lectures

Student name: _________ ___KEY_____________________

This 30-minute quiz is worth 5 points. I have extra paper, if you need. Write your name on every extra page and staple them together with this cover page.

1) - Define BMR and FMR and list the two key differences between them (+0.40):

BMR: Basal Metabolic Rate = amount of energy expended per unit time by an animal at rest, cost to keep things running, baseline for measuring activity costs
FMR: Field Metabolic Rate = amount of energy expended per unit time by a free ranging animal engaged in normal activities, expressed as a multiple of BMR

BMR "at rest": an adult animal, awake but not active, neutral environment, not digesting
FMR: not "at rest"

- Explain how BMR and FMR are used to quantify the energetic cost of different activities performed by seabirds. Provide specific values for swimming and flying (+0.20):

BMR provides a baseline, FMR is expressed as a multiple of BMR in order to express the energetic cost of different activities relative to the baseline.

Swimming: ~10x BMR
Flying: ~12x BMR

- Write down the power function relating BMR to body mass, and report the value of the exponent – determined from empirical data (+0.20):

$BMR = Mass^a$
$\ln(BMR) = a * \ln(Mass)$

$a = 0.719$

- Finally, list two other factors that influence BMR in seabirds and explain how (hint: what is the sign of the relationship, what are the differences amongst groups) (+0.40):

Phylogeny – direction of relationship varies, but seabird orders vary in their metabolic rates (e.g., penguins tend to have higher rates than other orders)

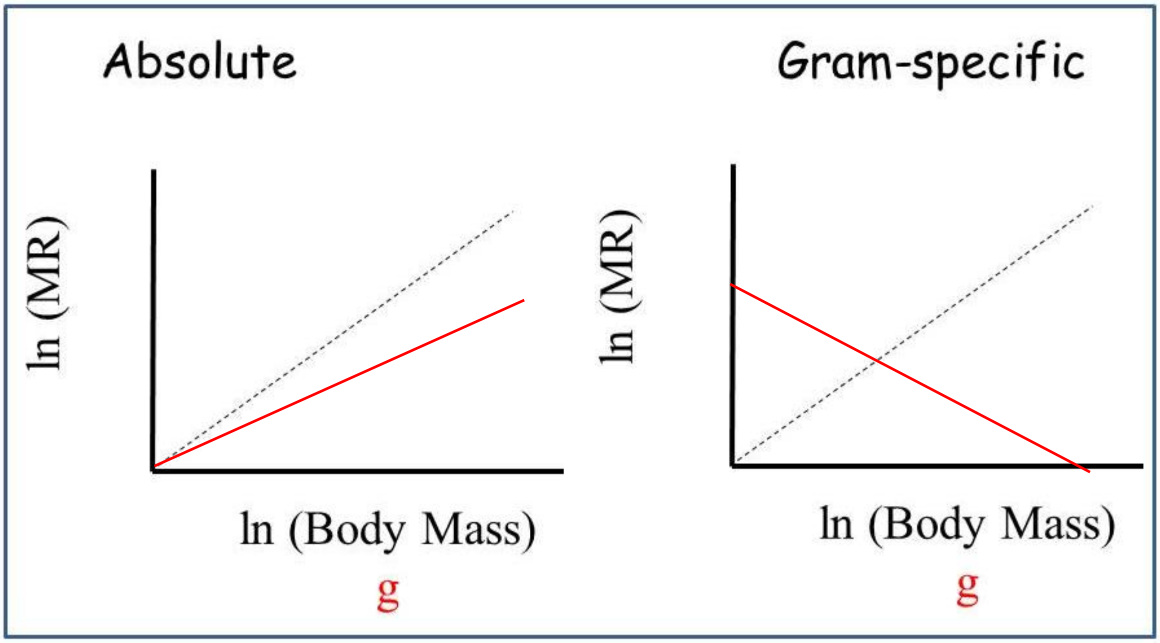
Latitude – BMR increases with latitude

Life span – BMR increases with life span
(species that live longer, have higher metabolic cates)

Intrinsic growth (r) – BMR increases with r
(species with higher rates of population increase, have higher metabolic rates)

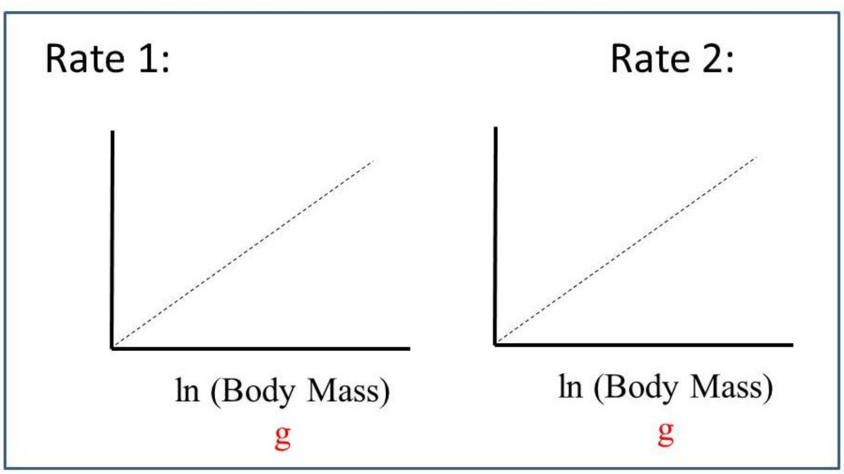
2) Show how the metabolic rate of a seabird scales with body size in absolute terms and in relative term (per gram of body mass) – Draw 2 curves and label the axes with the appropriate units (+0.40).

Y axis for graph 1 is in ml O_2 hr^{-1}, Y axis for graph 2 is in ml O_2 hr^{-1} g^{-1}
X axis for both is in g



Describe 2 Allometric scaling of physiological rates (other than metabolism) with respect to seabird mass. List the rates, plot the lines and label the axes (include units) below, making sure you consider the slopes of the lines (hint: is the exponent larger or smaller than 1) (+0.60).

Rate 1: ______________________ Rate 2: ______________________



For example: O_2 storage, fat storage, salt turnover, water turnover

3) Briefly explain the 5 ways these tropical birds are regulating their temperature behaviorally (+0.50):

Panting
Seeking out shade
Drooping wings
Facing into the wind
Exposing feet

Hint: what direction is the wind coming from (right or left)? How can you tell (+ 0.10):

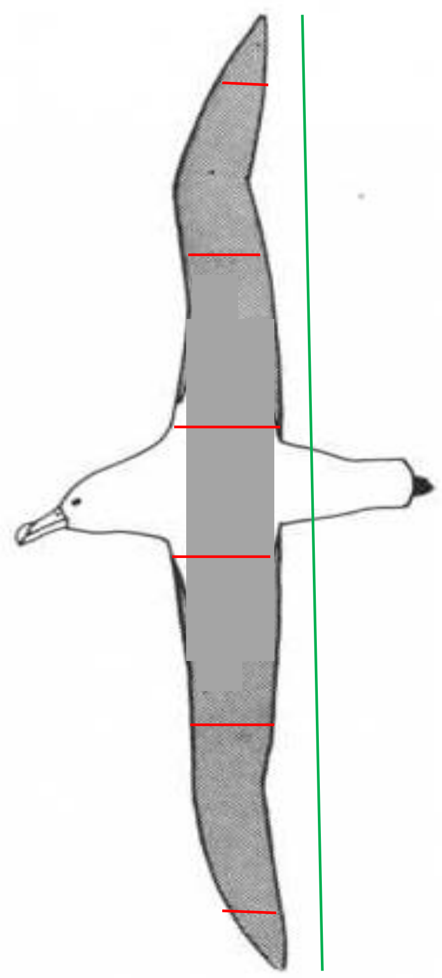
Right – the birds are facing into the wind

Briefly explain 2 physiological adaptations that allow seabirds to regulate their temperature by controlling the way their blood flows throughout their body. For full credit, provide specific examples of how deep diving seabirds (i.e. penguins) benefit from these adaptations (+0.40):

Countercurrent heat exchange: Warm blood flowing away from the body and into the feet warms the cool blood that is flowing away from the feet and back into the body. In diving birds, this helps reduce heat loss in cold water. Alternatively, the warm blood flowing away from the body is cooled as a result of intentional exposure of the feet. In diving birds, this helps reduce body temperature and therefore metabolic costs of diving.

Controlling blood flow to various body parts: Birds can increase or reduce blood flow to various body parts in order to reduce heat loss and minimize extraneous metabolic costs during diving. In deep diving birds, blood flow to pectoral muscles, brood patch, and other organs not necessary for diving is restricted to reduce heat loss to cold water and reduce metabolic costs. Blood flow to the brain and muscles necessary for diving is increased.

4) Define these 3 measurements of wing shape / size both in terms of standardized measurements. Draw and label these measurements in the bird provided (+0.20 each):



- Mean chord: The mean width of the wings, width being the linear distance from the leading edge to the trailing edge of the wings. Mean of red lines on drawing.

- Wingspan: The length of the wings from the tip of one wing to the tip of the other wing. Green line on drawing.

- Wing area: Mean chord x wingspan. Entire shaded area on drawing.

Define these 2 metrics of wing shape / size both in terms of the three standardized measurements listed above and explain their ecological significance for flight / diving (+0.20 each):

- Aspect ratio: wingspan / mean chord = length / width
  Defines the amount of lift a bird gets from the shape of its wings. Birds with high aspect ratio (long skinny wings) get more lift but are less maneuverable. Birds with low aspect ratio (short stubby wings) get less lift but are more maneuverable.

- Wing loading: body mass / surface area OR (total mass * gravitational acceleration) / surface area
  The loaded weight of the bird carried per unit area of the wings. Birds with high wing loading (small wings relative to body mass) have to operate at higher speeds and are less maneuverable. Birds with low wing loading (large wings relative to body mass) can operate

at lower speeds and are more maneuverable/

5) Compare multiple seabird species with different foraging methods. Answer the questions below using these data. Note: these data and units are correct – no tricks

Species Name	**Mass (g)**	**Wing Chord (mm)**	**Wing Span (mm)**	**Aspect Ratio**	**Wing Loading (N / mm 2)**	**Tarsus Cross Sections (mm)**
Common Murre	601	79	605	7.7	12.5	10 / 5
Sooty Shearwater	400	65	934	14.4	9.0	7 / 3
Red-tailed Tropicbird	500	102	915	8.9	5.3	6 / 5

Based on the aspect ratio data only, which of these species is best suited for gliding flight and which of these species is worst suited for gliding flight, explain why? (+0.2)

Best – Sooty Shearwater – highest aspect ratio means it gets the most lift, which is good for gliding
Worst – Common Murre – lowest aspect ratio means it gets the least lift, which is bad for gliding

Based on the wing loading data only, which of these species is best suited for diving and which of these species is worst suited for diving, explain why? (+0.2)

Best – Common Murre – highest wing loading reduces drag and increases diving propulsion
Worst – Red-Tailed Tropicbird – lowest wing loading increases drag and reduces diving propulsion

Based on the tarsus cross section data only, which of these species is best suited for swimming and which of these species is worst suited for diving, explain why? (+0.2)

Best – Sooty Shearwater – tarsus cross section is the most flattened and therefore the most hydrodynamic.
Worst – Red-Tailed Tropicbird – tarsus cross section is the most rounded and therefore the least hydrodynamic

Now, focus on this Sooty Shearwater, measured during its spring-time migration from New Zealand to Alaska. What will happen to this bird's flying / diving ability when it reaches Alaska, doubles in mass (from 400 to 800 grams) and starts to molt, losing the five outer primaries from each wing, so its wing area declines by 25% - Calculate change in wing loading – for full credit (+0.2) ?

The bird's aspect ratio will decrease due to decreased wingspan, while its wing loading will increase due to body mass gain that is much greater than wing area loss. It will lose some gliding (flying) ability but will become a better diver because of reduced drag and increased diving propulsion.

Wing loading = Bird Mass (kg) / Wing area (m2)

Before molting:

Wing area = 65 mm * 934 mm = 60710 mm ^{2}

Wing area = 0.065 m * 0.934 m = 0.060 m ^{2}

Mass = 400 g = 0.4 kg

Wing Loading = 0.4 kg / 0.06071 m^2 = 6.588 kg / m^2

During molting: Wing area reduced by 25%

Wing area = 60710 * 0.75 = 45532.5 mm ^{2}

Wing area = 45532.5 / 1000000 = 0.045 m ^{2}

Mass = 800 g = 0.8 kg

Wing Loading = 0.8 kg / 0.045 m^2 = 17.778 kg / m^2

So, what happened ? Mass increased by 100% and wing area decreased by 75%

Wing Loading During Molting / Wing Loading Before Molting = 17.778 / 6.588 = 2.69

Or, taking a short-cut, you can just look at the ratio of the changes:

(2 * mass) / (0.75 * wing_area) = 2.67