**Supporting information (S2): Mass-specific oxygen consumption (VO2 mass-specific) calculations**

**Summary**

The following provides supporting estimates of predicted body length, predicted body mass, VT, EO2, and TO2 per individual animal that were used to estimate VO2 mass-specific in Table 7.

**Prediction of body length and body mass from age**

We did not have direct body length measurements for the 11 killer whales in our study, and could not accurately measure it from the drone video. We therefore had to make a number of assumptions to predict body size and estimate mass-specific VO2.

Unknown sexes were assumed to be female based on the likelihood that young males have similar morphometrics to females in this sexually dimorphic species. Body length (m) was predicted from age as of 2020 using a Gompertz growth model per sex on published data (n=23, Table 1, Fearnbach et al., 2011). To clarify, we derived the Gompertz growth model based on n=43 southern resident killer whales in Fearnbach et al. (2011), then applied the resulting model growth curve to the 11 whales tagged in 2020 with different equations per sex. We predicted body mass (kg) from body length using Bigg and Wolman (1975) for each individual whale (note that this equation is not-sex specific).

The killer whales in our study were matched to whales (termed “proxy whales”) that had similar body masses per sex (Table 16, Kriete, 1995). As tidal volume is affected by body size, we only calculated VO2 mass-specific for animals that had predicted body masses that were reasonably matched within 15% of the body masses in Kriete (Table 16, 1995). Females A113, I129, and I145 were excluded from VO2 mass-specific calculations because their predicted body masses were more than 15% different (364-754 kg difference) than the predicted body masses and VT of the female killer whales in Kriete (Table 16, 1995). The predicted body mass of killer whale I129 also did not overlap with either of the females in Kriete (1995) and was off by approximately 386-409 kg depending on whether Yaka or Vigga was selected as the proxy whale (Table S2). The predicted body masses for all 4 males in our study ranged from 4172 to 3382 kg, but only males L87 and L88 were within 15% of the predicted body masses available in Kriete (males were 2,800 or 4,733 kg, 1995)

**Calculating mass-specific tidal volumes per animal**

Instead of assuming a constant fixed tidal volume per sex as 149 L for females and 258.5 L for males (VO2 fixed, Table 6), we chose the maximum tidal volume of the animal and the activity state in Table 1 (Kriete, 1995) that matched the predicted body mass of each of the whales tagged in the present study within 15% of the matched proxy whale (Table S2). Specifically, animals that differed in predicted body mass by more than 15% of their “proxy” whale in Kriete (1995) were excluded from VO2 mass-specific calculations. Notably, the body masses in Kriete (1995) were not measured directly, but rather estimated using the same equation as in our study (Bigg and Wolman, 1975) from measured body lengths (Table 16, Kriete, 1995).

Mass-specific VT for the resting behavioural state was from activity level 1 matched to the “proxy whale” that had a similar body mass within 15% (Table 9, Kriete, 1995). Tidal volume for activity level 2 on the males was not measured directly in Kriete (1995). Thus, for males only, we averaged maximum mass-specific VT from activity level 1 and 3 from only Hyak for activity level 2 for foraging and travelling (Table 1, Kriete, 1995). This contrasts to averaging both Hyak and Finna activity levels 1 and 3 for VO2 mass-specific.

**Calculating VO2 mass-specific**

The calculations for VO2 mass-specific were the same as for VO2 fixed except tidal volume for VO2 mass-specific was based on a tidal volume that was mass-specific per animal per activity level 1 or activity level 2 (VT = Table 1, body mass = Table 16, Kriete, 1995). A mass-specific VT resulted in mass-specific EO2 and TO2 estimates as well. This table also only includes tracks that were ≥ 10 min cumulative duration.

Mean oxygen extraction from inhaled air (EO2) for resting was from activity level 1, and foraging and travelling was from activity level 2 matched to the “proxy whale” that had an approximately similar body mass within 15% (Table 9, Kriete, 1995). Because VT varied by individual animal for VO2 mass-specific, EO2 (%) and oxygen uptake per respiration (TO2, L respiration-1) also varied per sex, per behaviour, and per individual animal on a mass-specific basis. For males only, EO2 for activity level 2 was averaged from activity levels 1 and 3 values for Hyak in Kriete (Table 9, 1995). Within the males, only whales L88 and L87 were included because the predicted body masses of I107 and D21 differed by > 15% from the male whale in Kriete (1995). The number of total tracks per behaviour are noted in Table 7. The number of animals per sex per behaviour varies depending on which animals exhibited each behavioural state (n=4 females, n=3 males across all behaviours). There was reasonable distribution of the animals across all behaviours except for foraging males. Foraging males VO2 mass-specific included only animal L87 because L88 did not have any foraging tracks. See Table 7 for the VO2 mass-specific estimates per behaviour.

# **S2 Table. Predicted body lengths, body masses, and calculated oxygen consumption for 11 northern and southern resident killer whales derived from age as of July 2020.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Whale ID** | **Sex** | **Age (yr)** | **Predicted body length (m) a** | **Predicted body mass (kg) b** | **Predicted Body mass (kg) of proxy whale to estimate VTc** | **Absolute body mass difference with proxy whale (kg, % difference)** | **Mass-specific maximum VT (L)d** | **Activity stated** | **Behavioural state** | **EO2  e (%)** | **TO2  f (%)** |
| R58 | Unknown (Female) | 9 | 5.3 | 2137 | 2005 (Vigga) | 132 (+7%) | 42.0 | Level 1 | Resting | 35.1 | 3.08 |
| 55.0 | Level 2 | Travelling | 40.1 | 4.61 |
| 55.0 | Level 2 | Foraging | 40.1 | 4.61 |
| A100 | Unknown (Female) | 9 | 5.3 | 2137 | 2005 (Vigga) | 132 (+7%) | 42.0 | Level 1 | Resting | 35.1 | 3.08 |
| 55.0 | Level 2 | Travelling | 40.1 | 4.61 |
| 55.0 | Level 2 | Foraging | 40.1 | 4.61 |
| D26 | Unknown (Female) | 10 | 5.4 | 2272 | 2005 (Vigga) | 267 (+13%) | 42.0 | Level 1 | Resting | 35.1 | 3.08 |
| 55.0 | Level 2 | Travelling | 40.1 | 4.61 |
| 55.0 | Level 2 | Foraging | 40.1 | 4.61 |
| R48 | Female | 14 | 5.7 | 2666 | 2800 (Yaka) | 134 (-5%) | 149.0 | Level 1 | Resting | 35.1 | 10.96 |
| 114.0 | Level 2 | Travelling | 40.1 | 9.57 |
| 114.0 | Level 2 | Foraging | 40.1 | 9.57 |
| I129 | Unknown (Female) | 11 | 5.5 | 2391 | 2005 (Vigga) | 386 (+20%) *excluded* | NA | NA | NA | NA | NA |
| I145 | Unknown (Female) | 6 | 4.7 | 1641 | 2005 (Vigga) | 364 (-19%) *excluded* | NA | NA | NA | NA | NA |
| A113 | Female | 4 | 4.3 | 1252 | 2005 (Vigga) | 754 (-38%) *excluded* | NA | NA | NA | NA | NA |
| L87 | Male | 28 | 6.8 | 4172 | 4733 (Hyak) | 561 (-12%) | 254.5 | Level 1 | Resting | 35.2 | 18.77 |
| 256.5 | Level 2 | Travelling | 41.2 | 22.11 |
| 256.5 | Level 2 | Foraging | 41.2 | 22.11 |
| L88 | Male | 27 | 6.8 | 4148 | 4733 (Hyak) | 585 (-12%) | 254.5 | Level 1 | Resting | 35.2 | 18.77 |
| 256.5 | Level 2 | Travelling | 41.2 | 22.11 |
| 256.5 | Level 2 | Foraging | 41.2 | 22.11 |
| I107 | Male | 16 | 6.4 | 3499 | 2800 (Finna) | 699 (+25%) *excluded* | NA | NA | NA | NA | NA |
| D21 | Male | 15 | 6.3 | 3382 | 2800 (Finna) | 582 (+21%) *excluded* | NA | NA | NA | NA | NA |

a Body length (m) was predicted from age using a Gompertz growth model per sex on published data of southern resident killer whales (Table 1, Fearnbach et al., 2011).

b Body mass (kg) was predicted from body length (m converted to cm) using Bigg and Wolman (1975).

c Whales in our study were matched to whales that had similar body masses per sex (Table 16, Kriete, 1995). Animals A113, I129, I145, I107, and D21 were excluded from VO2 mass-specific calculations because their predicted body masses were not within 15% of the predicted body masses and VT of the killer whales in Kriete (1995, Table 16).

d Maximummass-specific tidal volumes (VT) were matched based on similar body masses per activity level per sex from Kriete (Table 9, Table 1, 1995). VT for activity level 2 on the males was not measured directly in Kriete (1995). For males only, we averaged maximum mass-specific VT from activity level 1 and 3 from Hyak for activity level 2 for foraging and travelling.

e Meanoxygen extraction from inhaled air (EO2, %) for resting was from activity level 1, and foraging and travelling was from activity level 2 per sex (Table 9, Kriete, 1995). For males only, EO2 for activity level 2 was averaged from activity levels 1 and 3 values for Hyak because it was not directly measured in Kriete (1995). For all calculations, we assumed the proportion of oxygen in air was 0.2095.

f Oxygen uptake per respiration (TO2, L O2 breath-1) varies per animal by body mass and by activity state because it is based on mass-specific VT.

\*All values in the able are rounded for simplicity, but calculations were carried out without rounding digits.

**References**

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