Electronic supplementary material

Serendipitous observations from animal-borne video loggers reveal synchronous diving and equivalent prey capture rates in chinstrap penguins

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Supplementary Methods and Results

Contemporaneous location and dive records

Contemporaneous with the video logging described in the main text, we also recorded the locations and depths used by four breeding chinstrap penguins from Cape Shirreff, Livingston Island during the late incubation period. We tracked the birds using Pathtrack nanoFix-GEO GPS tags (52x23x18 mm, 25 g) paired with a small temperature-depth recorder (Lotek LAT1800FP, 36x13x10 mm, 10 g) using the attachment method described in the main text. We report raw GPS position estimates and diving records of these deployments (Fig. S1) to illustrate the foraging ranges and diving behaviors of chinstrap penguins from Cape Shirreff during the incubation period. The dive data from the two video-logging birds presented in the main manuscript and from a third chinstrap penguin tracked during the incubation period are also included for comparison.

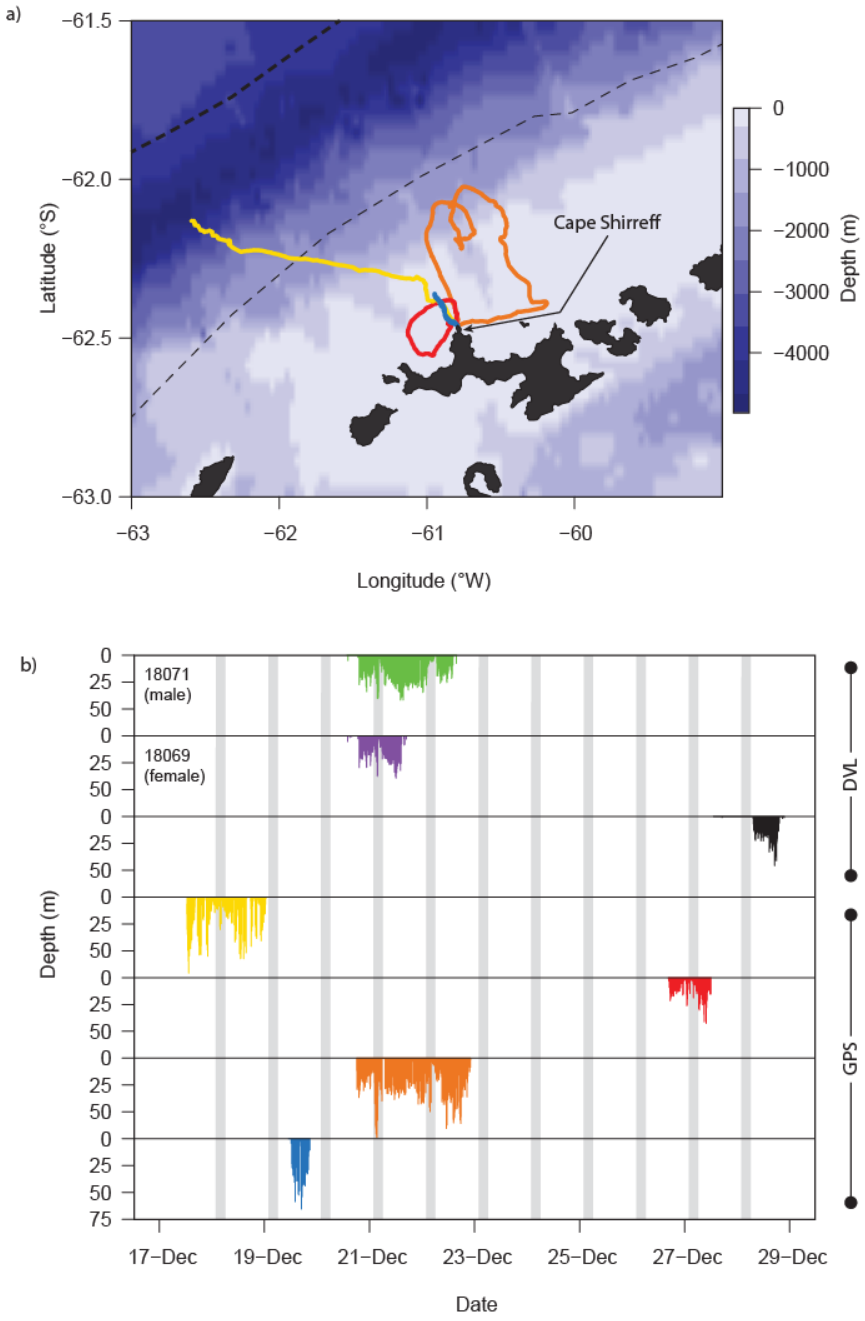

Fig. S1. Tracking and dive data for comparison between the two synchronously diving chinstrap penguins with other instrumented birds from this region collected in December 2019. a) Map of study locale and bathymetry overlaid with raw GPS positions from four adult chinstrap penguins tracked during the incubation period. The southern boundaries of the Antarctic circumpolar current (thin dashed line) and southern Antarctic circumpolar current front (thick dashed line) are shown for reference. b) Depth records from seven chinstrap penguins tagged with digital video loggers (DVL) or GPS loggers during the incubation period. Dives from the two synchronously foraging penguins are shown in the top two rows. The third bird tagged from the same year with a DVL is shown in the third row. Dives of the birds in the bottom four rows are colored to match their corresponding GPS trajectories shown in panel a.

Manual annotation of video

Manual video annotation was conducted by viewing the video in the freely-available VLC media player and marking dive and predation events on the corresponding depth record to the nearest second. For the purposes of this paper, annotators recorded the start and end time of transit periods, dives, the time of predation events on krill (*Euphausia superba*), fish, or unknown/unidentifiable prey, and the time of entry into krill swarms (indicated by high apparent densities of krill in view).

Prior to annotation of the video, all annotators were provided the same 4-step training materials taken from other video logger deployments on chinstrap penguins. The training protocols were intended to familiarize naïve annotators with the foraging behaviors of chinstrap penguins, practice identifying key dive and foraging behaviors in the video, hone annotation technique, and minimize differences in annotations by different annotators, to the extent practicable, prior to full annotation of the video data used here.

The first training step required a full annotation of 90 minutes of foraging video. The second step required annotators to articulate, in their own words, how they identified predation events. The third step required annotators to re-annotate a set of 5 consecutive dives from the video used in the first step, which had been identified as showing high variance in total predation counts across annotations. The final step was to evaluate a new, 60-minute video from a different chinstrap penguin. At each step, inter-annotator variation in classification of predation events, taken as the total number of krill strikes observed by each observer, was reduced from a coefficient of variation (CV) of 0.51 at step 1 to a CV of 0.11 at step 4, underscoring both

improvement and alignment of annotator skill, but also the inherent subjectivity of classifying predation behavior from visual cues alone. The CV for final annotations considered in the main manuscript was 0.089, showing further improvement with continued annotation. An example annotation for a 10-minute period by each annotator for the male and female chinstrap during their synchronous period is provided in Fig. S2.

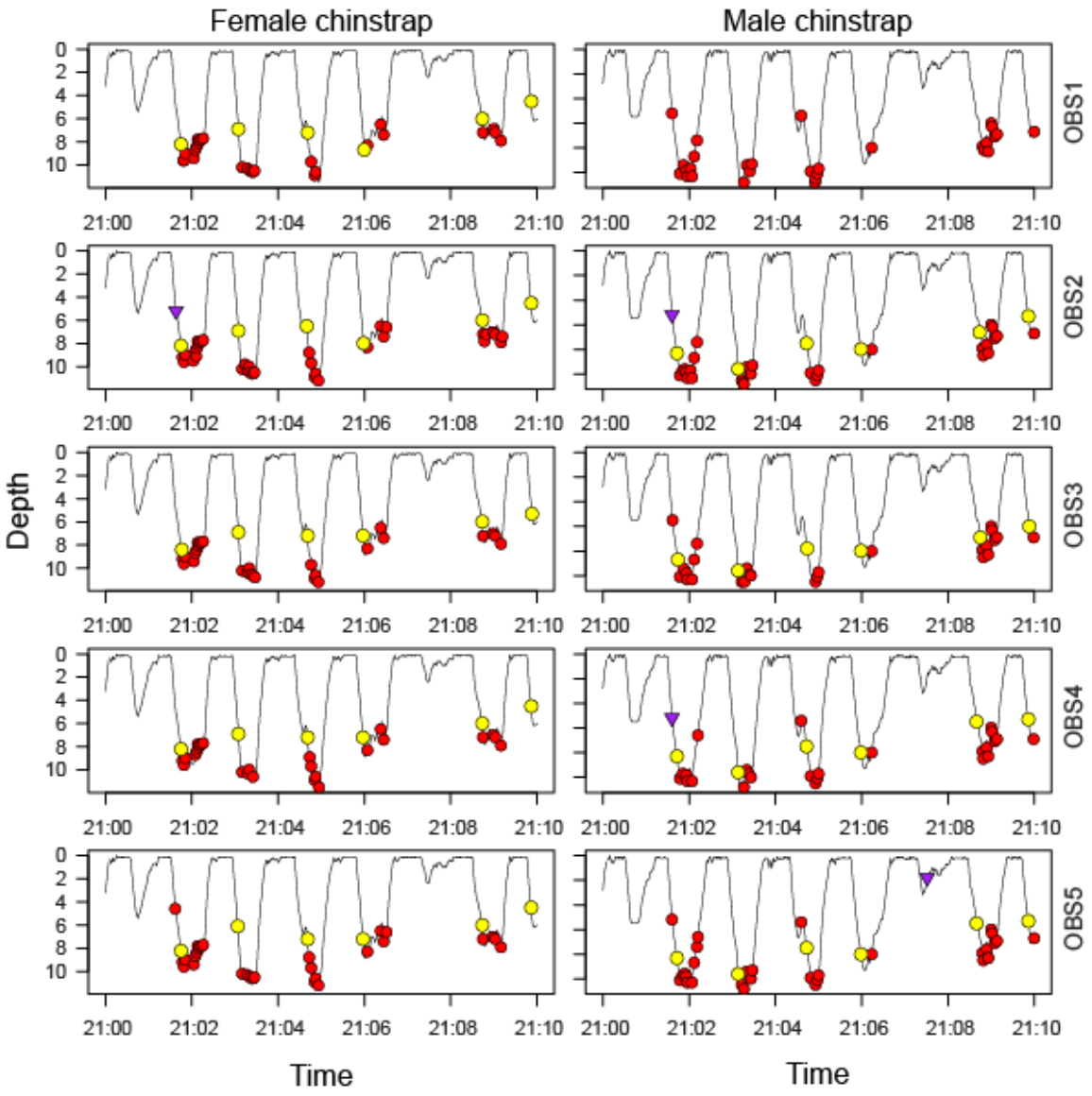

Fig. S2. Example annotations for each bird by each annotator (OBS1-OBS5) showing time and depth of krill strikes (red dots), unidentified prey strikes (purple triangles), and first encounter of a krill swarm (yellow squares).

Supplemental dive analyses

The timing of dive events (e.g., the timing of dive start and end, time when the bottom of the dive is reached, and time when ascent begins) was estimated with the R (R Core Team 2020) package 'diveMove' (Luque 2007). We used paired t tests to compare the timing of each dive phase from the set of paired dives identified in the main text and present the data in Fig S3. Results demonstrate minor differences between individuals. In general, the male tended to initiate diving 1.8 ± 0.26 s (95% CI) earlier (t_{209} = -13.6, p<0.01), reach the bottom of the dive up to 2.0 ± 0.63 s (95% CI) earlier (t_{209} = -6.3, p<0.01), and surface 1.8 ± 0.52 s (95% CI) later (t_{209} = 6.73, p<0.01) than the female (Supplementary Fig. S3). On average, there was no difference in the time when ascent started (-0.48 ± 0.93 (95% CI), t_{209} = -1.02, p=0.33).

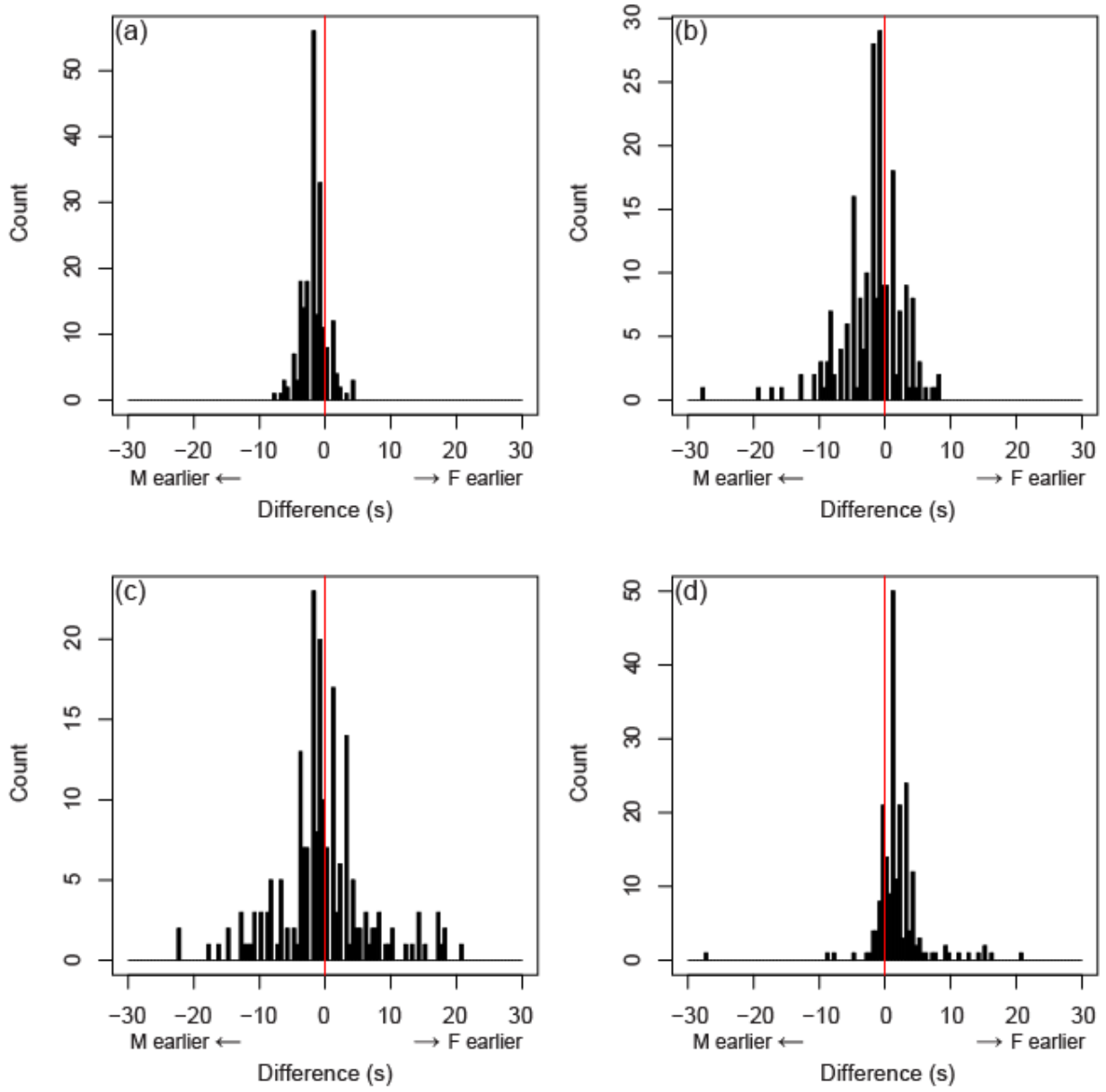

Fig. S3. Histogram of differences between the male and female chinstrap in the timing of (a) the start of the dive, (b) end of descent phase, (c) start of ascent phase, and (d) surfacing. Red vertical line references no difference in timing.

Group size and companion sighting

At no time during the video logging period were more than 5 individuals observed together. The image in Fig. S4 captures one such instance that occurred over one hour into the recorded foraging trip. Sightings of group members occurred regularly for the duration of the video logging period. We present example sightings from the entire video period in Fig. S5.

Fig. S4. Group size, as estimated from counts of penguins within the video frame, was small and likely ≤5 at all times. An instance of 5 individuals (including the individual wearing the camera that captured this image) travelling together was observed prior to the first dive bout, roughly 48 minutes after departing the colony. The bird with the other video logger is in the upper left of this photo. The bird with the flipper band cannot be identified in this group configuration.

Fig. S5. Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE). Captions describe the general activity observed in each photo.

Hour 18:00

Photo 1. Male CHPE swimming in shallow water near the colony behind the female CHPE prior to initiating transit to foraging areas.

Photo 2. Female CHPE looking toward a banded CHPE on land just before departure from the colony.

Photo 3. Female CHPE porpoising behind male CHPE on their transit from the colony

Photo 4. Female CHPE travelling behind male CHPE in transit.

Photo 5. Female CHPE travelling alongside banded CHPE.

Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE), continued. Captions describe the general activity observed in each photo.

Photo 6. Male CHPE behind both the female and banded CHPE in transit.

Photo 7. Male CHPE directly underneath banded CHPE in transit.

Photo 8. Female CHPE travelling behind male CHPE.

Photo 9. Male CHPE facing the female CHPE at the surface.

Photo 10. Female CHPE faces the male CHPE at the surface.

Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE), continued. Captions describe the general activity observed in each photo.

Photo 11. Female CHPE faces the male CHPE at the surface.

Photo 12. Female CHPE faces the male CHPE at the surface.

Photo 13. Male CHPE faces the female CHPE and possibly the tagged CHPE.

Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE), continued. Captions describe the general activity observed in each photo.

Hour 21:00

Photo 14. Female CHPE beginning a dive behind the male CHPE.

Photo 15. Male CHPE behind both the female and tagged CHPE as they head to the surface.

Photo 16. Male CHPE behind both the female and tagged CHPE as they head to the surface.

Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE), continued. Captions describe the general activity observed in each photo.

Hour 22:00

Photo 17. Female CHPE at the surface facing both the male and tagged CHPE.

Photo 18. Male CHPE behind both the female and tagged CHPE as they go to the surface (The tag can be seen in the next frame).

Photo 19. Female CHPE behind the male CHPE as they head up to the surface from a dive.

Supplemental photographic timeline of close proximity of tagged and banded chinstrap penguins (CHPE), continued. Captions describe the general activity observed in each photo.

Hour 23:00

Photo 20. Female CHPE faces the male CHPE at the surface.

Photo 21. Female CHPE behind the male CHPE as they head to the surface after a dive.