



Biparental Incubation Coordination of the Leach's Storm-Petrel (*Oceanodroma leucorhoa*)

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Study Species

Leach's Storm-Petrels (*Oceanodroma leucorhoa*)

- Burrow-nesting, sexually monomorphic procellariiforms that travel long distances from their breeding colonies to forage over the open ocean in bouts lasting days.
- Obligate biparental caregivers which alternate incubation shifts in non-overlapping bouts, remaining in the nest burrow to care for the single egg of the breeding season. Incubation lasts about 43 days. (Huntington et al. 1996)

Questions

- What factors influence the length and pattern of incubation and foraging bouts?**
- How do Storm-Petrel parents make decisions to balance individual effort and reproductive success?**
- How do schedules affect, or inform, the Storm-Petrel's ability to coordinate biparental care?**

Methods

- Conducted research within a long-term Leach's Storm-Petrel study site at the Bowdoin Scientific Station on Kent Island, New Brunswick, Canada.
- Monitored the burrow entrances and exits of pairs of actively incubating *O. leucorhoa* adults ($N_{\text{burrows}} = 4$, $N_{\text{adults}} = 8$) using passive integrated transponder (PIT) tags and recorders (Biomark, Inc., Boise, ID; Zangmeister et al. 2009; Fig. 1). PIT recordings ran from about 10 days after egg-laying through to hatching.
- Manually checked burrows, and latticed burrow entrances, to support PIT data interpretations and monitor hatch events.
- Analyzed data in R (R Core Team 2015), including ggplot2 (Wickham 2009).



Figure 1. Two of the three pieces of the PIT monitoring system: (A) The antenna surrounding an active Storm-Petrel burrow, which reads a tag's signal, and (B) the transceiver which timestamps and stores the signal. The PIT tags themselves, and associated leg bands, are not pictured.

Results

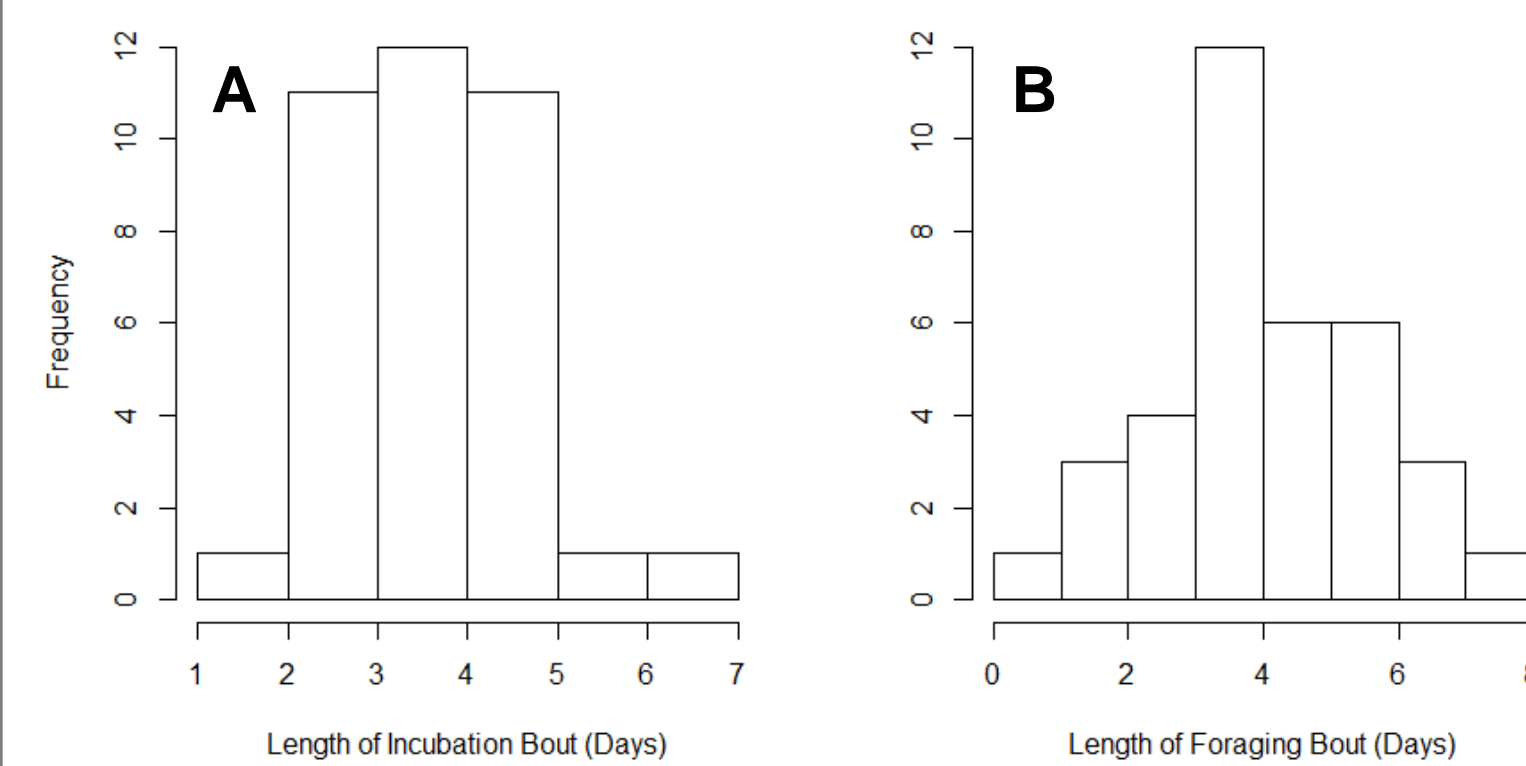


Figure 2. The frequency distribution of incubation (A) and foraging (B) bouts of different lengths were recorded using PIT tags on actively breeding *O. leucorhoa* adults. Bouts were recorded starting about 10 days after egg-laying and until the egg hatched. $N_{\text{adults}} = 8$, $N_{\text{incubations}} = 36$, $N_{\text{foragings}} = 36$.

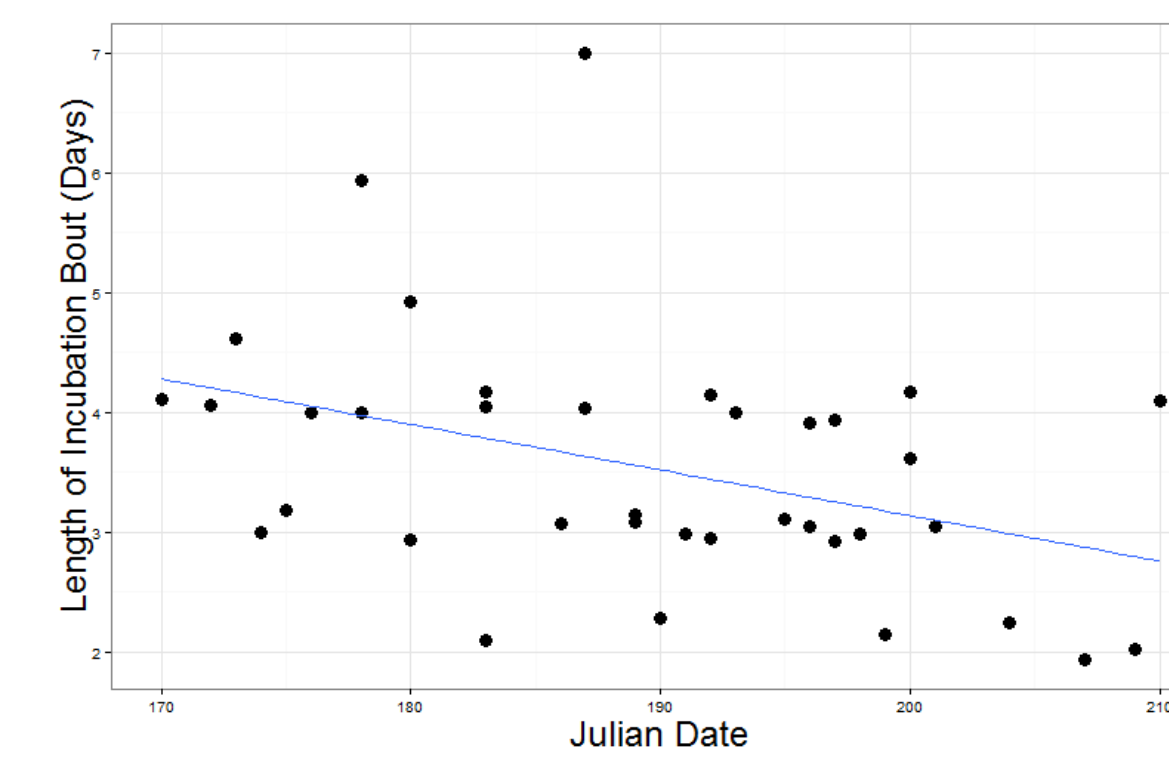


Figure 3. The relationship between the length of a given incubation bout of a breeding *O. leucorhoa* adult and the Julian date. Incubation bout length decreases significantly as the birds move further through the breeding season (Linear Regression, $R^2 = 0.1313$, $P = 0.0157$). ANCOVA analysis indicates that neither the individual ($P = 0.762$) nor the date's distance from hatching ($P = 0.688$) significantly influences the relationship. $N_{\text{adults}} = 8$, $N_{\text{incubations}} = 36$.

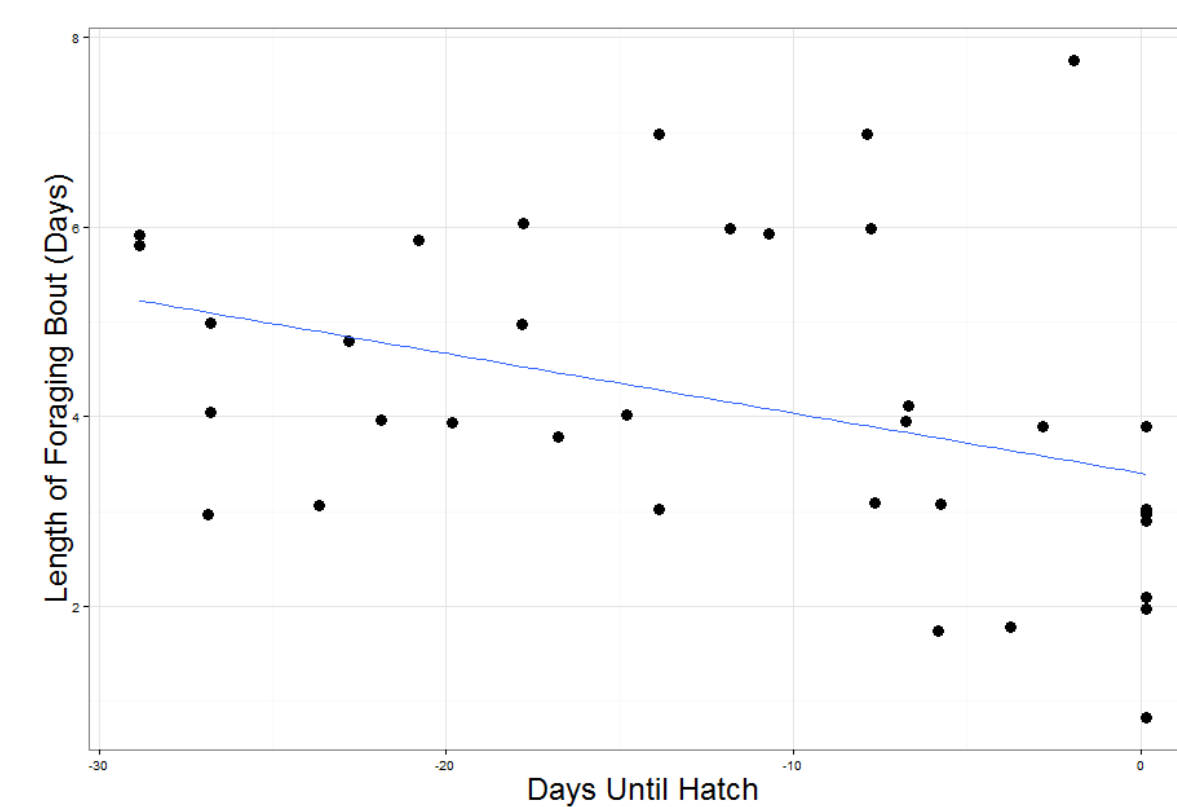


Figure 4. The relationship between foraging bout length of a breeding *O. leucorhoa* adult and the time until their egg will hatch. Foraging bout length decreases significantly as the birds' schedules shift closer to hatching (Linear Regression, $R^2 = 0.1414$, $P = 0.028$). ANCOVA analysis indicates that neither the individual ($P = 0.563$) nor Julian date ($P = 0.507$) significantly influences the relationship. $N_{\text{adults}} = 8$, $N_{\text{foragings}} = 36$.

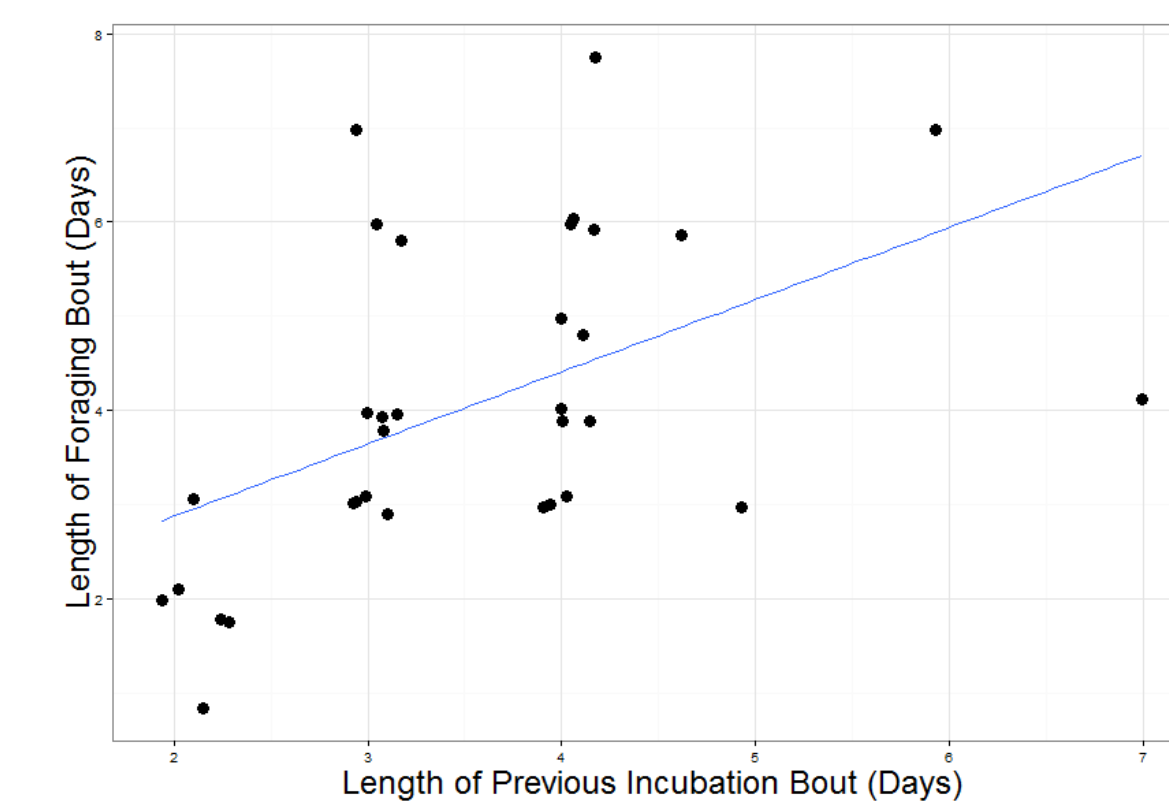


Figure 5. The relationship between the length of a given foraging bout of a breeding *O. leucorhoa* adult and that adult's most recent incubation bout. Longer incubation bouts are correlated with a significant increase in the length of the subsequent foraging bout (Linear Regression, $R^2 = 0.248$, $P = 0.003$). Individual birds do not have significantly altered relationships (ANCOVA, $P = 0.114$). $N_{\text{adults}} = 8$, $N_{\text{bout-pairs}} = 33$.

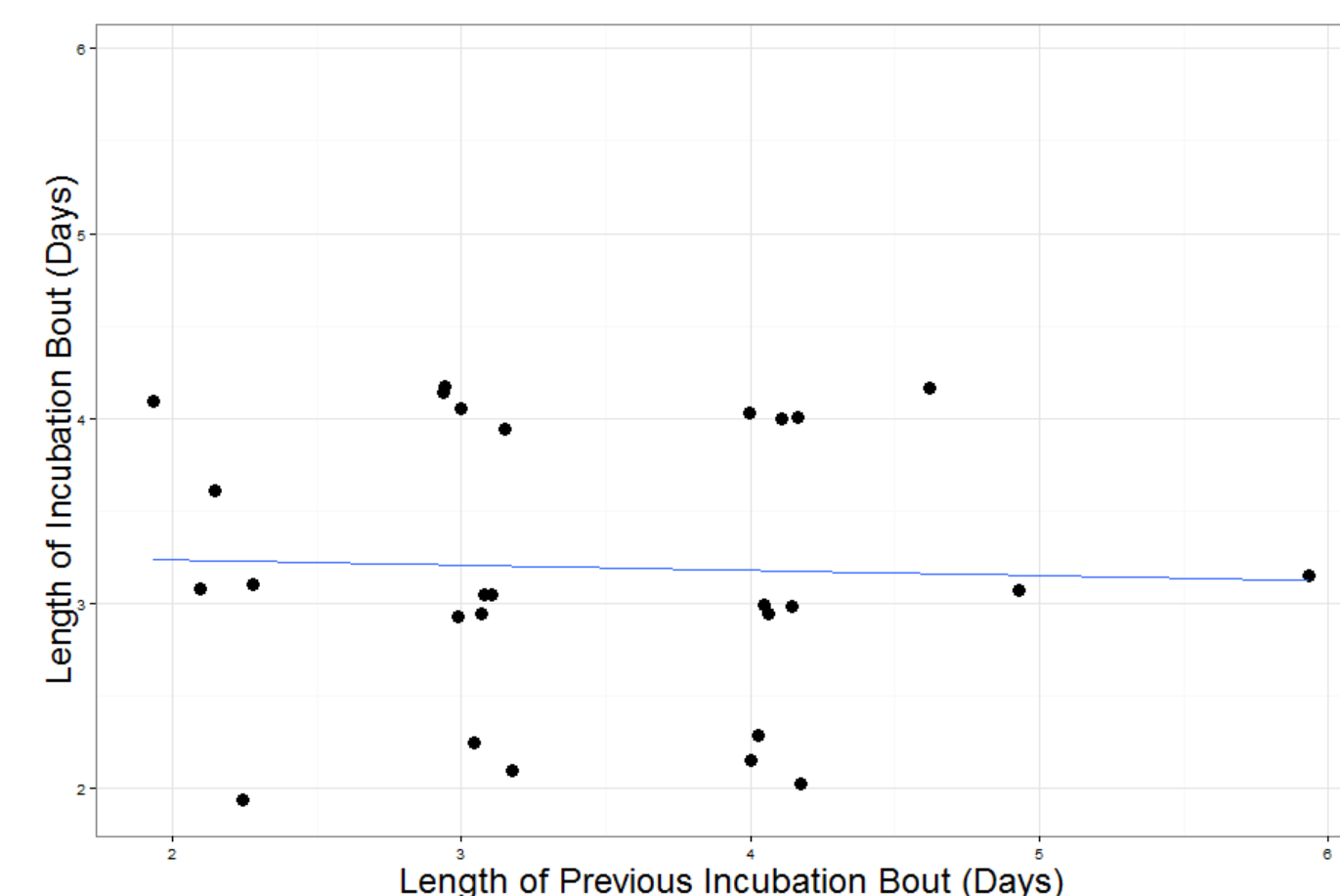


Figure 6. The relationship between the length of a given incubation bout of a breeding *O. leucorhoa* adult and that adult's most recent previous incubation bout. The most recent period of incubation does not significantly influence the length of a subsequent incubation bout (Linear Regression, $P = 0.600$). Individual birds do not have significantly different relationships (ANCOVA, $P = 0.5739$). $N_{\text{adults}} = 7$, $N_{\text{bout-pairs}} = 34$.

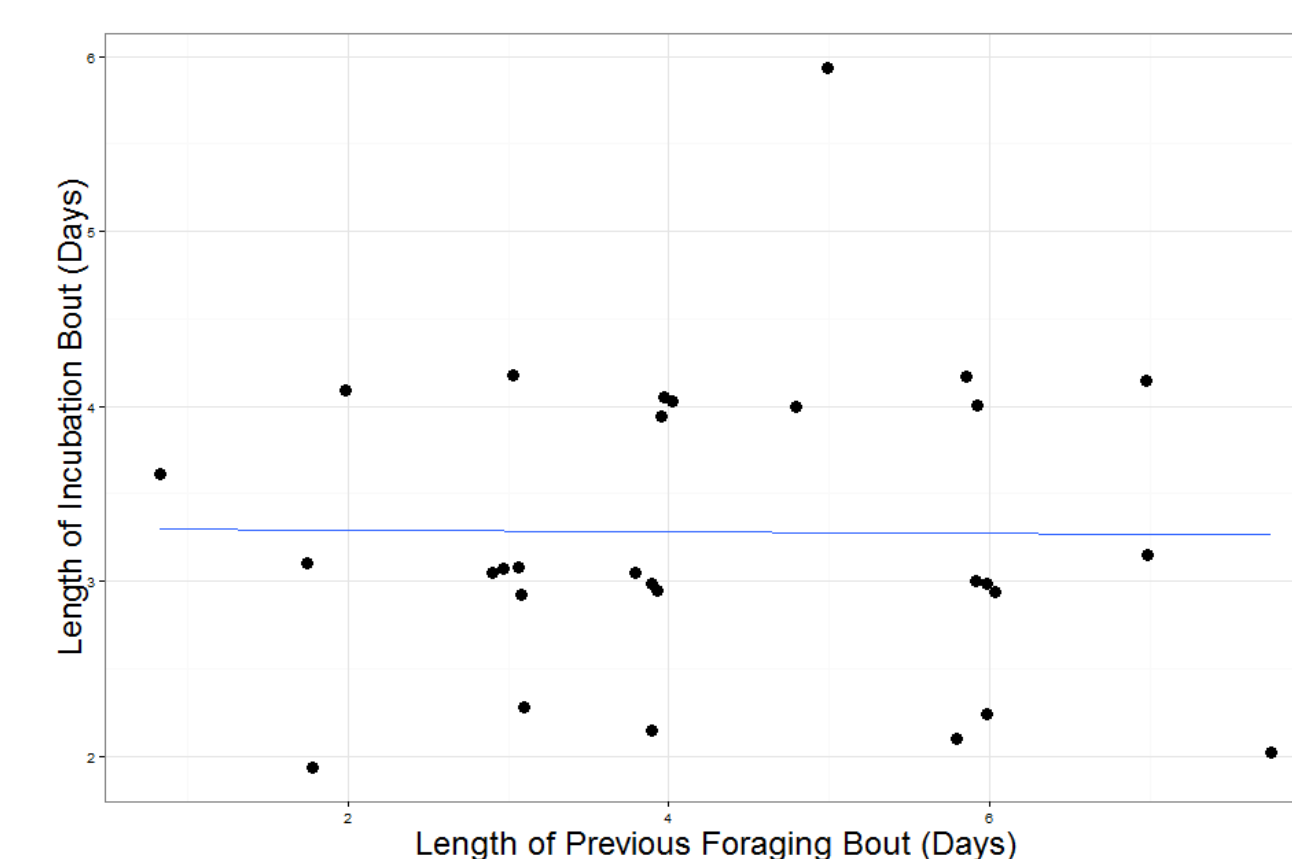


Figure 7. The relationship between the length of a given incubation bout of a breeding *O. leucorhoa* adult and that adult's most recent foraging bout. Recent time spent foraging does not significantly influence the length of a subsequent incubation bout (Linear Regression, $P = 0.961$). Individual birds do not have significantly different relationships (ANCOVA, $P = 0.4847$). $N_{\text{adults}} = 7$, $N_{\text{bout-pairs}} = 29$.

Conclusions

- Foraging and incubation bout lengths have a relatively small distribution (Fig. 2).
- While ending incubation is tied to the absolute distance into the breeding season (Fig. 3), the decision to stop foraging is more closely connected to the length of time the adult has been caring for the egg (Fig. 4). Thus, while both relationships may be influenced by temporal dynamics, incubation may be more affected by general activity at the nest site, climate, or other broader factors, whereas foraging schedules may be more strongly linked to the bird's personal breeding history.
- Energetic constraints may be the driving factor in an adult's decision to stop foraging, as parents forage for longer following a longer (and therefore more energy-intensive) incubation bout (Fig. 5).
- The coordination of incubation shifts, whether spurred by a mate's arrival or not, was not found to be connected to the most direct apparent information about the mate (as communicated by proxy via the previous incubation bout; Fig. 6). Additionally, direct energetic constraints may not influence the decision to stop incubation, as incubation bout length acts independently of the most recent foraging trips (Fig. 7).

Future Work

- Molecular sex differentiation to determine sex-based behavior differences in current and future data.
- Relationships between chick-care and incubation scheduling behaviors.
- Stochastic modeling, in which a population of programmed Storm-Petrels face parametrized energetic constraints with differential survival based on incubation coordination strategy.

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