Avoidance of nocturnal offshore travelling in shearwaters, demonstrates the importance of diurnal cues for homeward movements

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Many breeding seabirds commute between their colony and foraging areas by travelling several hundreds of kilometres over the open ocean. This requires that they have reliable cognitive mechanisms to achieve long-distance navigation in this often featureless environment. In some species of the families Procellariidae and Alcidae, homeward movements are expected to be organized not only spatially but also temporally because they return to their breeding colonies exclusively after dark to avoid diurnal predators. Our previous study indeed showed that streaked shearwaters (*Calonectris leucomelas*), of which foraging areas widely varied up to 600 km away from the colony, timed the start of their homeward movements depending on distances to the colony from the foraging areas. Thereby, their arrivals at the breeding island concentrated within a narrow time window after sunset. On the other hand, departures from the colony of streaked shearwaters were always at night but concentrated within several hours before sunrise. These temporal petterns suggest that they prefer diurnal travelling to nocturnal ones. In this study, we quantified the spatial and temporal patterns of homeward movements in streaked shearwaters breeding in the northeast of Japan, with the aim of investigating whether they avoid nocturnal travelling, and therefore use diurnal navigation cues, in homing journeys. In addition to analyses of fine-scale movement paths in foraging trips, we conducted displacement experiments in which birds were released from the sea at different times of the day. Results indicated that the birds avoided nocturnal offshore travelling by adjusting the onset time of homeward movements and the duration spent resting on the water surface so as to reach at least the mainland by sunset. The sun and other visual cues, which are thought to be one of the common mechanisms of avian navigation and/or flight control, may be associated with offshore travelling of the shearwaters. When flying at night, they seemed to depend on the coastline as a navigational aid. Thus, streaked shearwaters appeared to balance requirements for predator avoidance at the island and navigation in offshore travelling, by timing the onset of homing. This study demonstrated that careful analyses of high spatial and temporal resolution of movement paths under natural conditions, which is still lacking in avian homing/navigation researches, can help design effective experiments as well as understand the underlying mechanisms of animal movements.