

# The ecological responses of Rhinoceros auklet to the environmental events

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Long-term environmental changes (such as global warming and decadal oceanic regime shifts) and short-term environmental variabilities (such as inter- and intra-annual variabilities of Sea Surface Temperature; SST, and strength of currents, etc.) in the ocean may have a variety of impacts on marine species. Long-term environmental changes may occur the drastic shift of species composition and abundance of marine organisms, thus prey availability of marine top predators and the food webs. Short-term environmental variability, may cause a mismatch between prey distribution and the foraging sites of marine top predators or breeding timing. Seabirds are known to highly sensitive to those environmental events, and they are thought to respond by changing their food selection and foraging locations. The objective of this study is to study how the seabirds respond to the both long-term and short-term environmental events by adjusting their food selection and foraging locations. We investigated the bill-loads, chick growth, and foraging site selection of breeding seabirds of Rhinoceros auklets *Cerorhinca monocerata* at three breeding sites; Matsumae-Kojima island (located in the Tsugaru Warm Current, the Sea of Japan), Tai island (located in the Tsugaru Warm Current, Mutsu Bay), and Benten island (very close to the seasonal front area of the Tsugaru Warm Current and the Oyashio Cold Current, Pacific side of Tsugaru Strait).

In 2016 and 2017, the Japanese anchovies in bill-loads at Matsumae-Kojima island were low (0.5 to 22.1WW%, Okado et al. 2021), and it's also seemed to similar in 2019 at Benten island. On the other hand, in 2021 to 2023, the Japanese anchovies dominated in bill-loads in all islands around the Tsugaru Strait (26.3 to 100 WW %). This long-term trend in the utilization of the Japanese anchovies by breeding Rhinoceros auklets may be caused by the cold regime shift in 2014 and the recovery of stock size of Japanese anchovies after 2021. Chick growth was higher in the year when the Japanese anchovies are highly available, particularly at the breeding sites closer to the Pacific Ocean (Benten island and Tai Island). In contrast to the diet and breeding performance, foraging site selection did not differ between 2019 to 2023 in the auklets in all the breeding sites. The auklets in each island selected the specific, segregated, coastal sea area as their foraging site near each breeding sites, especially during 1day trips, and they also highly shared the similar foraging site at around the Point Esan in the Pacific coast during  $\geq 2$ days trips, during breeding period. After breeding period, the auklets from all breeding sites tend to highly select the Point Esan in the Pacific coast and further east area of Pacific Ocean with lower SST.

During breeding period, SST around their foraging sites varied interannually (approximately  $\pm 2^{\circ}\text{C}$ ), but the foraging sites of the auklets seem to consistent. Around their each specific foraging sites, small eddies, reversal way to the Tsugaru Warm Current, are known to develop consistently because of strong current flow and complex landscapes around the coast of Tsugaru straits. Around the area at Point Esan, the highly shared foraging site during  $\geq 2$ days trips and after breeding, the seasonal oceanic front of the Tsugaru Warm Current and the Oyashio Cold Current and coastal upwelling were constantly existing, thus, highly predictable and available in forage fishes for auklets. In particular, the area around Point Esan might be very important "hot spot" for the auklets around this region. Our results suggested that auklets had a passive / opportunistic response to the long-term environmental changes by altering their prey, but not change their foraging sites. In contrast, they actively select the area with their foods highly predictable and available, and respond to short-term variability, especially seasonal increases in SST, by selecting their foraging sites actively. Our findings may provide important insights of the foraging strategies of seabirds in the highly variable environments. In further, this information would significantly benefit in clarifying important marine areas for top marine predators around this region.

## References

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