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学 位 論 文 題 名

Study on a recolonizing population of sea otters (*Enhydra lutris*) in eastern Hokkaido: feeding habits and the effects of a major environmental disturbance upon them
（北海道東部におけるラッコ（*Enhydra lutris*）の再定住個体群に関する研究：食性と大きな環境撹乱の影響）

Sea otters (*Enhydra lutris*) are keystone species and dietary generalists able to adjust their diets in response to prey availability. Their feeding behavior is thus an excellent indicator of marine ecosystem health. Recolonizations after extirpations due to the fur trade have shown sea otters' potential to transform ecosystems. In eastern Hokkaido, a mother and pup were first observed in 2014, and the population has grown gradually since. This has raised concerns about conflicts with fisheries. In fall 2021, a massive red tide caused major environmental disturbance, offering a unique opportunity to assess changes in sea otter feeding ecology. This study aimed to reveal how resource viability is impacted by this new ecological presence and explore potential coexistence moving forward.

Sea otter population trends are tied to carrying capacity, and comparisons with Alaska can help predict the future of the Hokkaido population. In Alaska, rapidly recolonizing sea otters often disrupted ecosystems by overexploiting prey, requiring shifts in diet and behavior such as deeper and longer dives. Chapter 1 compares feeding dive behavior in eastern Hokkaido with North American populations to assess ecosystem impacts and prey availability. I analyzed observational data from 2019 to 2023. Hokkaido otters showed shallower and shorter feeding dives than their counterparts elsewhere.

In Chapter 2, red tide impacts on the benthic community and sea otter diets were investigated. Benthic invertebrate samplings were conducted in 2020, 2022, and 2023, and focal observations of sea otter feeding dives from 2020 to 2023. In 2022, a significant decrease in benthic sea urchins was observed, leading to their disappearance from otter diets. The bivalve population increased that year, along with a doubling of their dietary percentage. In 2023, sea urchin densities slightly

increased, while bivalves slightly decreased. Dietary sea urchin and bivalve percentages returned to pre-red tide levels, indicating a temporary shift. The lack of lasting impact on bivalves or sea otter numbers suggests minimal change in local population health.

In Chapter 3, changes in sea otter feeding behaviors in response to regularly changing environmental conditions, such as seasonal life cycles of marine canopy covering plants, or to the stochastic red tide event and its associated dietary composition shifts were observed. In the study area, the canopy mainly consisted of sargassum and eelgrass, with less kelp. Canopy cover declined gradually between June and July, and then drastically by September. Sea otters did not show a change in distance from feeding location to canopy cover across seasons, indicating they do not seasonally alter their association with canopy plants, even as the location and distribution of those plants change. The red tide did not affect feeding dive duration; however, handling time per prey item and the number of prey items per dive significantly increased afterward. This shift is likely tied to increasing dietary percentages of bivalves and small prey items. The percentage of dives involving tool use also decreased after the red tide, possibly due to the increased bivalve proportion in the diet and a reduction in sea urchins.

This thesis shows that feeding behavior in eastern Hokkaido resembles newly recolonizing sea otter populations that primarily forage on bivalves in mixed sediment seafloors along the west coast of North America. The Hokkaido population demonstrated resilience to environmental disturbance, temporarily shifting from sea urchins to greater reliance on preferred bivalves. Such dietary plasticity may benefit the population as climate change increases the frequency of environmental disturbances. However, future red tides and marine heatwaves could affect prey availability in other ways. This research can help guide mediation between the economic needs of local fisheries and communities in eastern Hokkaido and the interests and health of a recovering sea otter population—valuable members of a long-absent ecosystem.

As described above, the applicant's study has significantly advanced our understanding of the ecological role of sea otters as keystone species and their interactions with marine environments and fisheries in eastern Hokkaido. By examining the feeding ecology and behavioral flexibility of a recolonizing sea otter population before, during, and after a major environmental disturbance, this research has offered key insights into ecosystem resilience and the implications of climate-driven events such as red tides. The applicant’s findings contribute not only to marine ecology but also to broader discussions on balancing conservation efforts with the socioeconomic needs of coastal communities. We highly evaluated these results and concluded that JOHNSTONE Jackson Brooks is a sincere, dedicated researcher with sufficient qualifications for a doctoral degree and is suitable for a Doctor of Philosophy (Environmental Science).