Title:	Ecology of immature octopus Enteroctopus dofleini: Growth, movement and behaviour
Other Titles:	ミズダコ未成体の成長、移動および行動に関する生態学的研究
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Abstract: This thesis considers the physiological and behavioral phenomena associate with the biannual migrations of immature Enteroctopus dofleini (Wülker, 1910) commonly known as the North Pacific Giant Octopus on and off the south coast of Hokkaido. Experiments were done in Usujiri, Minamykaiyabe where coastal temperatures range from 0℃ in January, February, and March to 21℃ in July, August, and September. Immature (3g-9㎏) E. dofleini are found in the coastal waters above 30 m when water temperatures are between 5 and 12℃. When water temperatures are outside this range, octopuses move offshore into deeper water, so there is a biannual inshore-offshore migration pattern. Chapter 1. Juvenile and immature E. dofleini found inshore in southern Hokkaido are often confused with O. conispadiceus and O honkongensis. Identification of immature octopus is difficult because they lack the three important features used to identify adults: a very long ligula; dark longitudinal grooves along the orange/red mantle; and small non-protruding eyes. Here E. dofleini is distinguished by features unique to immature animals, such as light skin colour and characteristic white patches, and other features that are common to both mature and immature animals. Chapter 2 Part A considers the effect of temperature on energy input, somatic storage and expenditure by monitoring the food ingestion, growth and respiration of captive immature octopuses. Three different experiments were conducted. The first tested the oxygen use of starved inactive acclimatized individuals in a dark flow though chamber. The second tested the effectiveness of different diet regimes by measuring intake, growth and faecal production of captive octopuses fed different amounts and types of food. The third experiment was a calculation of the energy budgets of animals living at 7, 9.5 and 12℃. Consumption and growth were measured and the results of the previous two experiments were used to calculate basic metabolic rates and devise appropriate diets for optimal growth. The results suggest that a mixed low lipid diet of approximately 3% body weight provided every 3 days and temperatures of 7-9.5℃ lead to more energy being available to fuel growth and activity. Chapter 2 Part B is a brief description of the growth rates of juvenile and immature individuals from long-term maintenance of 5 g - 5 kg E. dofleini. Time from hypothetical settlement to potential maturity (1g -15 kg) differed depending on temperature however in general; E. dofleini growth is best described by an exponential curve in the juvenile phase and a linear rate in the immature phase. With these results it is confirmed that E. dofleini in southern Hokkaido take approximately 30 months to reach maturity from the time they settle. Chapter 3 Part A is a description of behaviours seen in captivity. The behaviours are organized into 16 activity levels (from resting to continued fighting) that are scaled according to awareness, responsiveness, movement and (apparent) energy consumption. Chapter 3 Part B investigates behavioral response in terms of space use, interactions and activity of immature E. dofleini at 2, 5 and 7℃. Locations and interactions between octopuses kept in captivity were recorded on the hour for ten days. Recording was done by hand and video. Temperature was shown to influence space use, which in

turn influenced interactions between octopuses. As temperature increased territorial behaviour (physical defence of home areas) increased and larger octopus became more dominate (has greater access to preferred areas). Chapter 4 describes the daily movement patterns of immature E. dofleini at the entrance to Funka Bay. Three radio acoustic buoys (Vemco Ltd) set in a 300 m equilateral triangle, less than 500 m, offshore recorded locations of eight tagged immature E. dofleini from mid April to late June 2003. Tagged octopuses showed movement patterns that suggest foraging occurred within a 250 m2 area (home range), and that they spent 42% of their time within a mean area of 46m2 (core area). The Discussion deduces that the seasonality of E. dofleini around southern Hokkaido as noted in local seasonal culinary specialties, occurrence in fishermen's nets and the scientific literature: Kanemaru 1964; Kanemaru and Yamashita 1969; Hartwick et al 1978; Yamashita 1975, is a behavioral response to changes in water temperature. Only juvenile and immature octopuses migrate inshore, taking advantage of the seasonal temperature fluctuation while inhabiting small temporary home ranges. The rocky shore line provides immature octopuses with many potential den opportunities while heavy vegetation lowers visibility and ample but small prey items contribute to a large percentage of time foraging within small home ranges. Interpretation of the results of the present studies suggests that the biannual migration of immature E. dofleini in southern Hokkaido can be explained with reference to energy balance and behaviour. During summer, a combination of decreased feeding rates and increased metabolic activity created by high coastal water temperatures keep the octopuses offshore. In late fall when coastal water temperatures decrease to 12℃, octopuses are able to migrate back inshore. The octopuses stay inshore until increased metabolic activity can no longer be balanced by increased feeding. From January to April, octopuses are found only offshore in deep waters where temperatures (around 5℃) are higher than they are along the coast. In spring when coastal temperatures increase above 5℃, octopuses migrate inshore staying on the coast until temperatures become less adverse.