UNIVERSITY OF CALIFORNIA

SANTA CRUZ

INVESTIGATIONS ON THE WATER BALANCE AND ASSIMILATION EFFICIENCY OF THE NORTHERN FUR SEAL (*CALLORHINUS URSINUS*)

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Brian Scott Fadely

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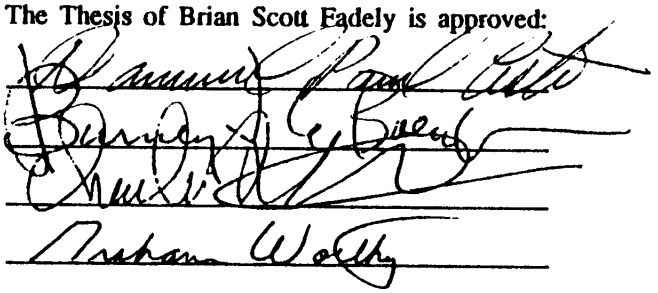
The Thesis of Brian Scott Fadely is approved:



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CHAPTER 1. WATER AND SODIUM TURNOVER AND THE CONTRIBUTION OF SEAWATER INGESTION TO WATER BALANCE IN THE NORTHERN FUR SEAL (CALLORHINUS URSINUS)

INTRODUCTION

Marine mammals in general, and most specifically pinnipeds, must cope with a wide range of environmental conditions which may stress the limits of homeostasis (Harrison and Kooyman 1968). Pinnipeds breed in and range between icy polar and desert temperate habitats (King 1983), undergo at-sea foraging bouts of a few days to several months (Le Boeuf et al. 1972; Gentry and Holt 1986; Le Boeuf et al. 1986), and may fast onshore while breeding for periods of up to 3 months (Le Boeuf and Peterson 1969; Gentry 1970; Bonner 1984). This wide range of environmental conditions confounds the evaluation of pinniped water balance requirements, and as a result the role of seawater ingestion has been widely debated. Determining the contribution of seawater ingestion to their overall water balance is especially important in light of isotopic determinations of free-ranging food intake and metabolic rate, as seawater ingestion can cause overestimates (Costa 1987).

Investigations into whether marine mammals drink seawater as a required part of their water balance cover nearly 8 decades. Portier (1910) inferred from urine freezing points that his study seals had ingested seawater, but subsequent laboratory studies of plasma and urine electrolyte concentrations concluded that seawater ingestion was either not required or could not be utilized in fasting or feeding harbor seals (*Phoca vitulina*) to excrete the electrolyte loads from feeding on fish or invertebrate diets (Irving et al. 1935; Smith 1936; Fetcher 1939; Fetcher and Fetcher 1942; Albrecht 1950; Bradley et al. 1954). However, Wolf et al. (1959) cautioned that determining water balance requirements from plasma and urine concentrations may be erroneous, and are not conclusive of the presence or absence of mariposia. Recent validation studies on California sea lions (*Zalophus californianus*) and northern fur seals (*Callorhinus ursinus*) utilizing isotopic tracers have generally found good agreement between estimated food intake and actual food intake, indicating minimal seawater ingestion occurred (Costa and Gentry 1986; Costa 1987).

Depocas et al. (1971) directly quantified seawater ingestion in fasting and fed harbor seals. The amount ingested averaged 9% of their total water intake, and was considered incidental to food intake. Other studies measuring seawater intake have reported a wide range of ingestion rates, suggesting mariposia may at times have a significant role in water balance (Carpenter 1968; Telfer et al. 1970; Costa 1982; Hui 1982).

Field observations also suggest a varied dependence on seawater ingestion. Ortiz et al. (1978) determined that weaned fasting northern elephant seals (*Mirounga angustirostris*) apparently satisfied all of their water needs exclusively with oxidative water, even though they had access to seawater. Conversly, Weddell seal pups (*Leptonychotes weddellii*) apparently ingested some seawater while suckling (Tedman and Green 1987). Observations of California sea lions, northern fur seals, Steller sea lions (*Eumatopias jubatus*), and Australian fur seals (*Arctocephalus forsteri*) in a variety of habitats indicate that at the beginning of a fast, seawater ingestion may be important to sufficiently dilute and excrete nitrogenous waste products from protein catabolism (Gentry 1981). Gentry (1981) also observed that mariposia was more frequent in members of the same species inhabiting warmer climates than in cool climates. Additionally, investigations on perinatal fast energetics of free-ranging Galapagos fur seals (*Arctocephalus galapagoensis*) measured greater water flux than could be accounted for by oxidative water production, indicating that mariposia occurred (Costa and Trillmich 1988). However, equivalent measurements of the Antarctic fur seal (*Arctocephalus gazella*) during the same life history period detected only minimal seawater ingestion (Costa and Trillmich 1988). These field studies support the contention that ingestion of seawater in pinnipeds is varied.

As a first step in determining conditions when seawater ingestion significantly contributes to the overall water balance of an otariid, I quantified the contribution of seawater ingestion relative to other water influx sources in fed captive northern fur seals. This study also functioned as a validation of tritiated water and isotopic sodium (^{22}Na) turnover to determine food intake in the field. These isotopes have been applied in this combination to several terrestrial systems as a method for estimating food intake in free ranging animals. (Green et al. 1978; Green and Eberhard 1983; Green et al. 1984; Green et al. 1986; Grigg et al. 1986; Costa and Gentry 1986; Tedman and Green 1987).