

MSEAS Seminar Series

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Towards Scalable Modern Marine Ecosystem Monitoring

Abstract: The practice of equipping free-living animals with data loggers to study their behavior in-situ dates back to the 1930s. Since then, remarkable advances in sensor miniaturization, power efficiency, data storage, and wireless communication have transformed the field. They are widely used in ecology and conservation to collect detailed information on animal movements, behavior, physiology, and the environments they inhabit. Despite these advances, scaling biologging studies remain constrained by data recovery in remote regions lacking cellular infrastructure. Researchers typically face a trade-off between two imperfect approaches: lower-cost archival tags suitable for short-term deployments (days to weeks), which require labor-intensive manual retrieval, and satellite tags designed for long-term deployments (months), which enable remote data transmission but remain prohibitively expensive for large sample sizes. In this seminar, I present two systems that I developed to address these limitations. Each system targets one side of this trade-off and aims to facilitate larger-scale, cost-effective deployments. First, I introduce ALERT (Automatic LoRa-Enabled Radio Tracker), a custom-built radiotelemetry system incorporating Long Range Wide Area Network (LoRaWAN) communication. ALERT automates the recovery of traditional archival biologgers by continuously scanning for non-coded VHF signals, detecting tagged individuals using an adaptable algorithm, and wirelessly transmitting presence data to a central gateway for real-time monitoring. The system was fieldtested at Atka Bay, Antarctica, from November 2024 to January 2025, where it successfully alerted researchers in real time to the return of emperor penguins (*Aptenodytes forsteri*) equipped with archival loggers and VHF transmitters, thereby facilitating efficient tag recovery. Second, I present a low-cost, mesh-capable IoT tag that I developed as an alternative to long-term satellite telemetry. Designed for multi-month deployments on central-place foragers such as emperor penguins, the system records GPS data locally and relies on LoRa-based peer-to-peer communication to exchange data opportunistically when tagged individuals encounter one another. As animals return to their colony during breeding, incubation, and chick-rearing phases, accumulated data is automatically offloaded to a central gateway via LoRaWAN. In this part of the seminar, I present the conceptual framework, agent-based modeling used to assess feasibility, the design and prototyping of the first tag version, and initial validation tests conducted on a surrogate species, highlighting the potential of a cooperative telemetry network to enable scalable, cost-effective long-term biologging in remote environments. By integrating mechanical design, the latest IoT technologies, and ecological insight, this work advances biologging toward low-cost, scalable solutions tailored for remote and logistically challenging environments. By removing key logistical and financial constraints, these approaches enable larger-scale data collection and provide a stronger empirical foundation for understanding and conserving remote ecosystems.

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4:00 PM EDT; Rm. 5-314

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Host:
Pierre Lermusiaux
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