An Acoustic Archival Tag for Long-Range Tracking Of Small Fishes

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Submission: December 20, 2017; Published: April 26, 2018

Abstract
This mini review describes the development of an acoustic tag for long-range (tens to hundreds of kilometers) tracking of small fishes or other marine animals. Tracking is achieved by standard RAFOS triangulation using the arrival times of unique sound signals emitted by moored sources. The tag also records temperature and pressure. All functions of the tag are controlled by an application specific microchip. The collected acoustic and sensor data are stored in a non-volatile memory. A cylindrical hydrophone of 25.4 mm length and 10.7 mm diameter also serves as housing for all electronic components. Power is provided by 2 button cell batteries, which enable an active tag lifetime of approximately two years.

Introduction

Much has been learned about the behavior of fishes during the past few decades through various kinds of data storage tags (DSTs), which were attached either externally to the back of the fish, or subcutaneously (e.g. Metcalfe [1], Block [2]). By recording in-situ physical parameters such as temperature, depth and light intensity, the geographical position can be inferred on the basis of retrospective analysis of known hydrographic features of the animal’s environment or light level for surface species. However, such retrospective positioning is invariably imprecise because physical features may vary only slightly (horizontally, and vertically in higher latitudes) or be poorly known (at least for purposes of retrospective positioning). During the first decade of the new millennium, a new technology emerged, which allowed equipping the tags with compact high frequency acoustic transmitters, each transmitting a unique ID code. When a fish tagged with such a transmitter passed within the acoustic range of a moored stationary receiver, a record of that event was kept. While fish cannot be tracked continuously this way, this widely used technology provided valuable insight into the overall range and timing of their movements [3].

To track submerged objects over much longer distances, Rossby [4] pioneered a new approach more than 30 years ago with his SOFAR floats, that passively listened for scheduled acoustic transmissions from anchored sound sources (Rossby [5], whose narrow-band emissions, centered at 260Hz, could be detected tens to hundreds of kilometers away depending on the physical conditions of the sound channel. The selected 260Hz range renders signal absorption insignificant and avoids most of the low-frequency ambient noise Urick [6], Wenz [7]. Each RAFOS float keeps a record of the arrival times of the precisely timed sound signatures. The source distance can then retroactively be inferred by multiplying the travel time of each sound signature by its known propagation speed.

The Fish Tag

Thanks to the continuing reduction of the transistor dimensions in microelectronic circuits (Moore’s Law), it is now possible to implement the complex acoustic arrival time detector of a RAFOS float on a tiny microchip. While in its most active mode when the tag is searching for sound signatures, the chip dissipates approximately 70µW, but the stand-by power is not more than 4µW. Assuming a realistic duty cycle of 10% (e.g. searching for sound signatures for 6 minutes every hour), the average power dissipation amounts to just 10-11µW. Two 1.5-volt button cell batteries of 80mAh capacity can thus keep the system running for more than 2 years. The microchip also houses a thermal sensor as well as a pressure sensor interface to assess depth. The sensors utilized in the fish tag yield a resolution of 0.05 °C and approximately 0.7 PSI (~0.5m), respectively. If so desired, pressure and temperature can be sampled more frequently than searching for sound signatures. A more detailed description of the chip’s features and its design can be found in reference Fischer [8].

Accurate timing is critically important in anytime-of-flight based positioning system. Since the fish tag’s energy capacity is severely limited, it uses a low power commercial watch crystal oscillator.
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Field Test Results

A series of field tests have been conducted during the course of this project to validate the performance of the tag in its various stages. The first was a preliminary test designed to evaluate the critically important analog preamplifier and the potential tracking range. In this experiment, source and receiver were kept below the surface mixed layer at ~40 and 30m, respectively, on the New England shelf south of Nantucket. At a distance of 70km from the hydrophone to be 180dB re 1μPa at 1m. It was therefore no surprise that none of the tags detected a signal emitted from any of the three farthest source sites located 72 -130km away.

The recordings revealed a remarkably small spread in signal propagation times, 0.053-0.132 seconds. This corresponds to a spatial uncertainty range of not more than 200m.

Conclusion

The presented fish tag, with a length of approximately 4cm similar in size to other archival tags, operates according to standard RAFOS tracking principles: it detects and records the arrival times of signals transmitted from moored sound sources. Navigational accuracy is determined by how well clock errors in the tag can be controlled, but can be kept quite small thanks to knowing total drift error and temperature of the crystal clock during mission. The two main drawbacks of the presented tagging technology are the cost for the sound infrastructure and the need to retrieve the tag to upload the archived data. At a future time, we will explore how to avoid the second drawback by adapting the tag to a miniature satellite transmitter and a release mechanism, which allows the device to float to the surface at the end of mission. The added bulk means this technology will be best suited to larger species.

Acknowledgement

This work has been supported by subsequent NSF/OTIC awards 0326907, 1061083 and 1435698. Funding by the Rhode Island Endeavor Program for two cruises is gratefully acknowledged.

References

1. Metcalfe JD, Arnold GP, Holford BH (1994) The migratory behavior of plaice in the North Sea as revealed by data storage tags. ICES CM, pp. 13.
2. Block BA, Dewar H, Blackwell SB, Williams TD, Prince ED, et al. (2001) Migratory movements, depth preferences, and thermal biology of Atlantic bluefin tuna. Science 293(5533): 1310-1314.
3. VEMCO (2009) VEMCO Acoustic Telemetry – New User Guide, DOC-004934-01, pp. 1-22.
4. Rossby HT, Dorson D, Fontaine J (1986) The RAFOS System. J Atmos Oc Tech 3: 672-679.
5. Rossby HT, Ellis J, Webb DC (1993) An efficient Sound Source for wide-area RAFOS Navigation. J Atmos Oc Tech 10: 397-403.

6. Urick RJ (1983) Principles of underwater sound. Peninsula Publishing, Los Altos, California, USA, pp. 423.

7. Wenz GM (1962) Acoustic ambient Noise in the Ocean. J Acoustic Soc Amer 34(12): 1946-1956.

8. Fischer G, Rossby T, Moonan DW (2017) A miniature acoustic Device for Tracking small marine Animals or submerged Drifters. Journal of Atmospheric and Oceanic Technology 34(12): 2601-2612.

9. Blanchard WF (1991) Air navigation systems Chapter 4. Hyperbolic airborne radio navigation aids – A navigator’s view of their history and development. J Navig 44(3): 285-315.

10. Fischer G, Lee S, Obara M, Kasturi P, Rossby HT et al. (2006) Tracking Fishes with a microwatt acoustic Receiver – An archival Tag Development. IEEE J Oc Eng 31(4): 975-986.

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DOI: 10.19080/OFOAJ.2018.07.555707

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