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Using Acoustic Telemetry to Document English Sole Movements: Application to Management of Contaminated Sediments

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Assessments of estuarine and marine fish exposure to contaminated sites have traditionally relied on indirect evidence, such as the capture of sentinel species in these areas or the presence of high contaminant levels in various fish tissues. Along the Pacific Coast of North America, English sole (*Parophrys vetulus*) are used as a sentinel species because they are broadly distributed in benthic habitats where they would contact contaminated sediment. English sole are also an effective sentinel species because they seem to show high fidelity to feeding areas, migrating only in winter for spawning. Strong correlations between sediment polycyclic aromatic hydrocarbons (PAHs) and the prevalence of neoplastic and preneoplastic liver diseases in English sole collected from contaminated areas also suggest high site fidelity. However, the amount of time adult English sole spend in contaminated areas and the spatial extent of their summer feeding movements have never been assessed directly.

We tested the use of acoustic telemetry to document the time individual English sole spent in contaminated areas and whether they showed interannual fidelity to these sites. This work was conducted in Eagle Harbor, a small, PAH-contaminated embayment of Puget Sound (Figure 1). This site was selected because it has been the subject of an ongoing study of sediment contamination and its effects on fish health. In 1994, a contaminated subtidal area of Eagle Harbor was covered with a cap of clean sediment (Figure 1). Subsequent testing for toxicopathic lesions and several direct measures of PAH exposure in English sole trawled from this embayment were used to determine whether remediation was successful. Now estimates of English sole home range are needed to more precisely link the degree of contaminant exposure with fish health. Acoustic telemetry in this small study area seemed to be a logical tool for documentation of English sole movements in and around contaminated sites.

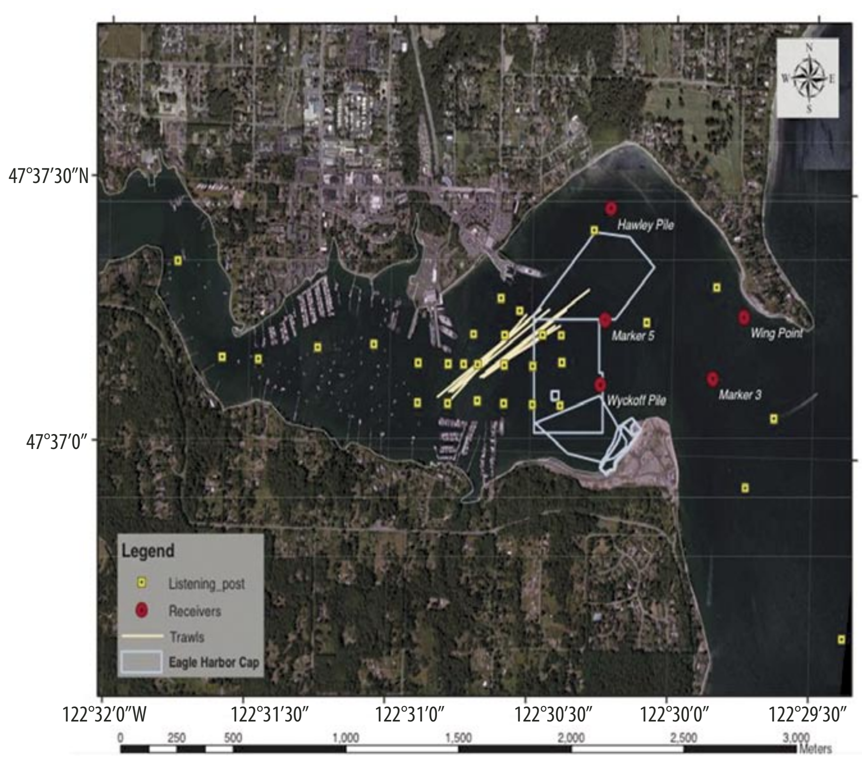
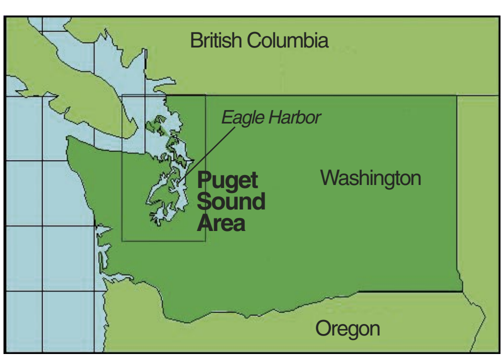


Figure 1. Aerial view of Eagle Harbor in Puget Sound with fixed receiver locations (red), mobile listening posts (yellow), trawl lines (white), and location of the sediment cap (light blue) denoted.



Initial laboratory experiments in 2003 verified that acoustic transmitters could be surgically implanted into adult English sole without tag expulsion or negative effects on survival or feeding within the first month of tagging. In the summers of 2003 and 2004, we trawled adult English sole from Eagle Harbor and surgically implanted uniquely coded acoustic transmitters in 39 of the largest (>27 cm) fish. The transmitters (Vemco V8 series, Shad Bay, Nova Scotia) were 9 × 30 mm cylinders weighing 5 g. We tested both high (147 decibels, or dB) and low (139 dB) power transmitters set at a variety of pulse intervals (20–60 s, 40–120 s, and 180–360 s).

After their release near the capture site, the sole were detected during periodic scans of set listening posts with a portable receiver (Vemco VR60) or by a continuously scanning array of underwater receivers (Vemco VR2) (Figure 1). We also tested use of a three-dimensional positioning system (Vemco VRAP, Vemco's radio acoustic position system) to document small-scale (on the order of meters) sole movements. The positioning system was deployed in Eagle Harbor near the known locations of two English sole and two stationary transmitting beacons were also deployed nearby. Position information for the four targets was taken over a 24-hour period, with the hope of observing diel patterns of fish movement.

Surgical implantation of the transmitters seemed to work well, particularly in the second year when fish were allowed to recover from surgery in a submerged cage for several days prior to release. The fixed receiver arrays detected all but one of the English sole that exited Eagle Harbor and provided valuable information on the diel and seasonal patterns of fish movement. The low-power transmitters set at a 20–60 s pulse interval proved most useful. The low power reduced transmission collisions (which result in the inability to identify fish codes) and improved spatial resolution, while the shorter burst interval reduced the time needed to scan listening posts. In addition, these transmitters had an extended battery life, which allowed us to document the return of English sole to Eagle Harbor in the second and third summers of the project.

Our study was limited by the inability to develop accurate, high resolution (<100 m) maps of English sole home range from mobile tracking. The time-intensive process of scanning listening posts would have been easier with a receiver that automatically triangulates fish position (expensive). We needed daily or even hourly calibration of transmission range, due to the effects of passing algal blooms and ferry traffic in this acoustically challenging study area (time consuming). An automated system to conduct and incorporate these calibrations would result in more accurate home range delineation. Tag miniaturization would also allow study of a greater size range of English sole.

Downloading receiver arrays, which in some cases required dive operations, would have been eased by the addition of wireless communication with the receivers. Cell phone links would allow downloading from the laboratory and reduce the need for expensive boat and dive operations. The usefulness of data obtained from the fixed receiver arrays was constrained by the large (over one second per day) and unpredictable amount of drift in receiver time stamps. This is a common problem among logging receivers and should be remedied.

Finally, we were disappointed with the results from the VRAP system. In addition to the high cost of this equipment and the expertise needed to set it up, we found that its application was very restricted. The system was most accurate ($\pm$1.5 m) when stationary targets were inside the relatively small envelope of system reception (a triangle of 450 m on a side). Precision of stationary target location outside of this envelope was unsatisfactory ($\pm$60 m). Thus, the system was strongly dependant on the position of the fish, which move relative to the hydrophone array. Dynamic position referencing, via onboard GPS or referencing stationary pingers perhaps, would greatly improve the performance of systems like VRAP. Although this technology shows great promise, we did not pursue its use further due to results of this trial.