Jun 21st, 1:50 PM - 2:10 PM

Evaluation of Two Acoustic Telemetry Signal Types on Fish Passage Studies

Tracey Steig
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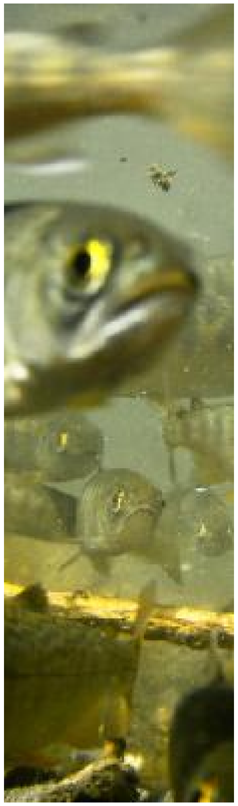

Evaluation of Two Acoustic Telemetry Signal Types on Fish Passage Studies

Presented by Tracey Steig
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Presentation Overview

This talk will describe two different types of acoustic tags.

Comparisons of these acoustic tags will include:

- **Signal Type**
- **Operating Frequency**
- **Source Level**
- **Pulse Repetition Rate**
- **Signal Absorption**

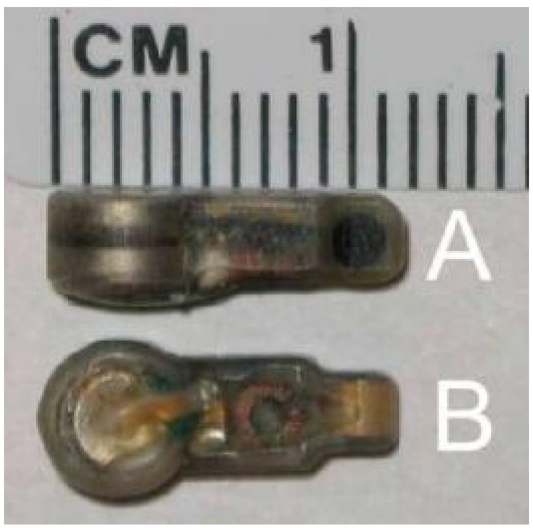
Detection Ranges of these acoustic tags will be estimated for the following conditions:

- **Increases in water velocities**
- **Increases in environmental noise**

Examples of the effect of the signal pulse width on detection range will be presented.

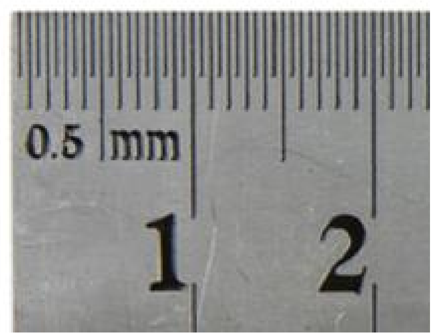
Tag Characteristics Comparisons

- JSATS Type Tag
- Tag Characteristics
- Frequency = 416.7 kHz
- Signal Type: 31 Bit Binary Phase-Shift Keyed (BPSK)
- Pulse Width = 0.744 msec (0.024 msec per bit)
- Source Level = 156 dB (re 1 uP @ 1m)
- PRI = 3 sec (manufacturer programmable 2-10 sec PRI)
- Freshwater Absorption = 55 dB/km

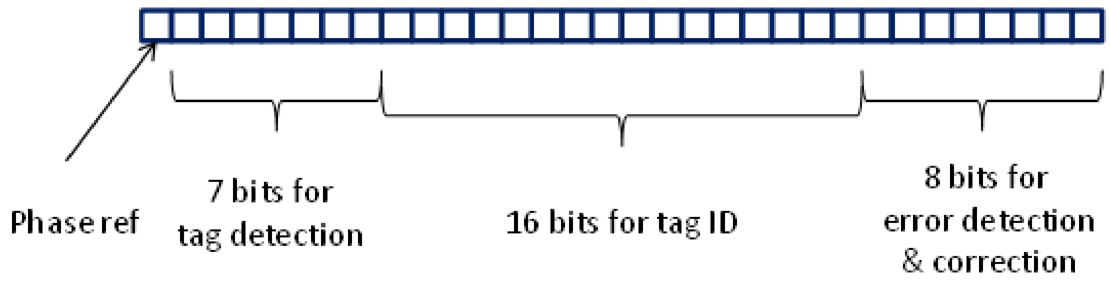


Taken from McMichael et. al. 2010.

- HTI Type Tag
- Tag Characteristics
- Frequency = 307 kHz
- Signal Type: Period Encoding
- Pulse Width = 1 msec (user programmable 0.5 msec – 5 msec)
- Source Level = 148 dB (re 1 uP @ 1m)
- PRI = 3 sec (user programmable 0.04 sec (25pps) – 16 sec PRI)
- Freshwater Absorption = 28 dB/km



JSATS Signal Type - Tag ID is encoded in each transmitted signal using differential phase coding



Bit structure for 31 bit Binary Phase-Shift Keyed (BPSK)

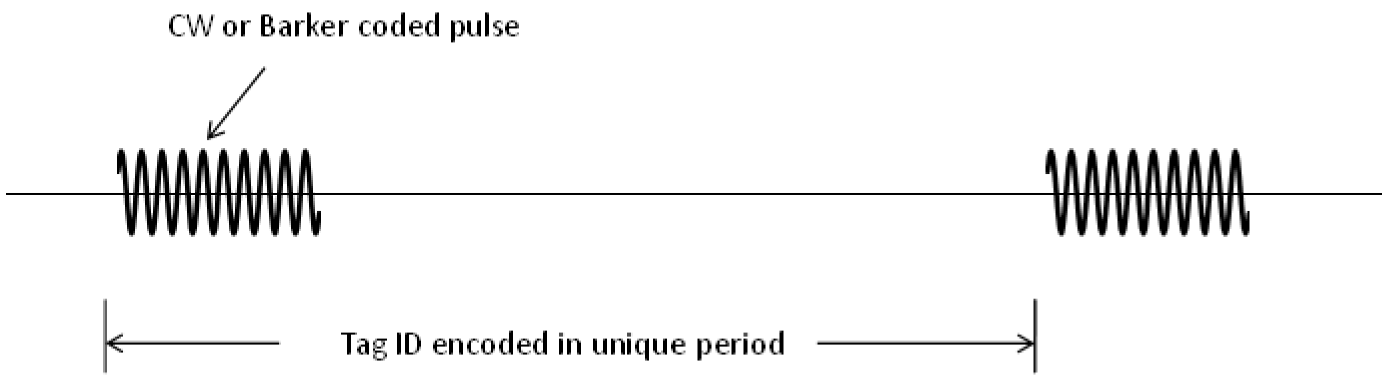
Advantages:

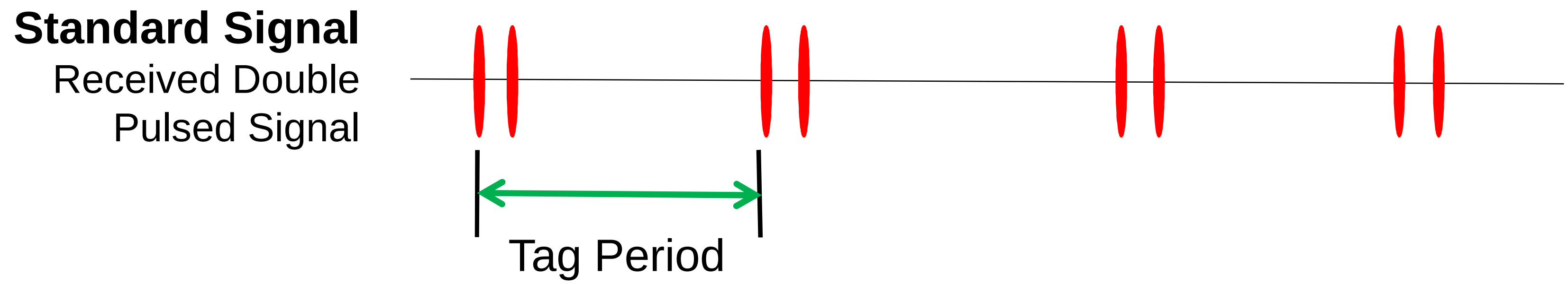
- **Each transmission contains the unique tag ID**

Disadvantage:

- **The energy in the transmitted signal is partitioned into segments used for tag detection and tag identification. This adversely affect both the detection and identification performance of the tag. The effect is greatest for tag ID where only a small fraction of the total energy goes into each bit which must be correctly decoded to obtain the proper ID**

HTI Signal Type - Tag ID is encoded in the period between pulses





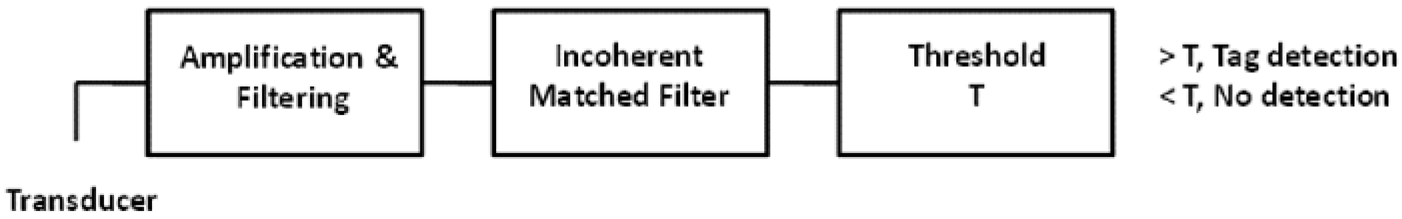
Advantages:

- **All the signal energy is available for tag detection, tag identification and tag tracking**

Disadvantage:

- **Tag identification requires reception of multiple tag transmissions to measure period and uniquely ID the tag**

Detection of a tag signal at a hydrophone



Detection performance is dependent on the signal–to-noise ratio, SNR

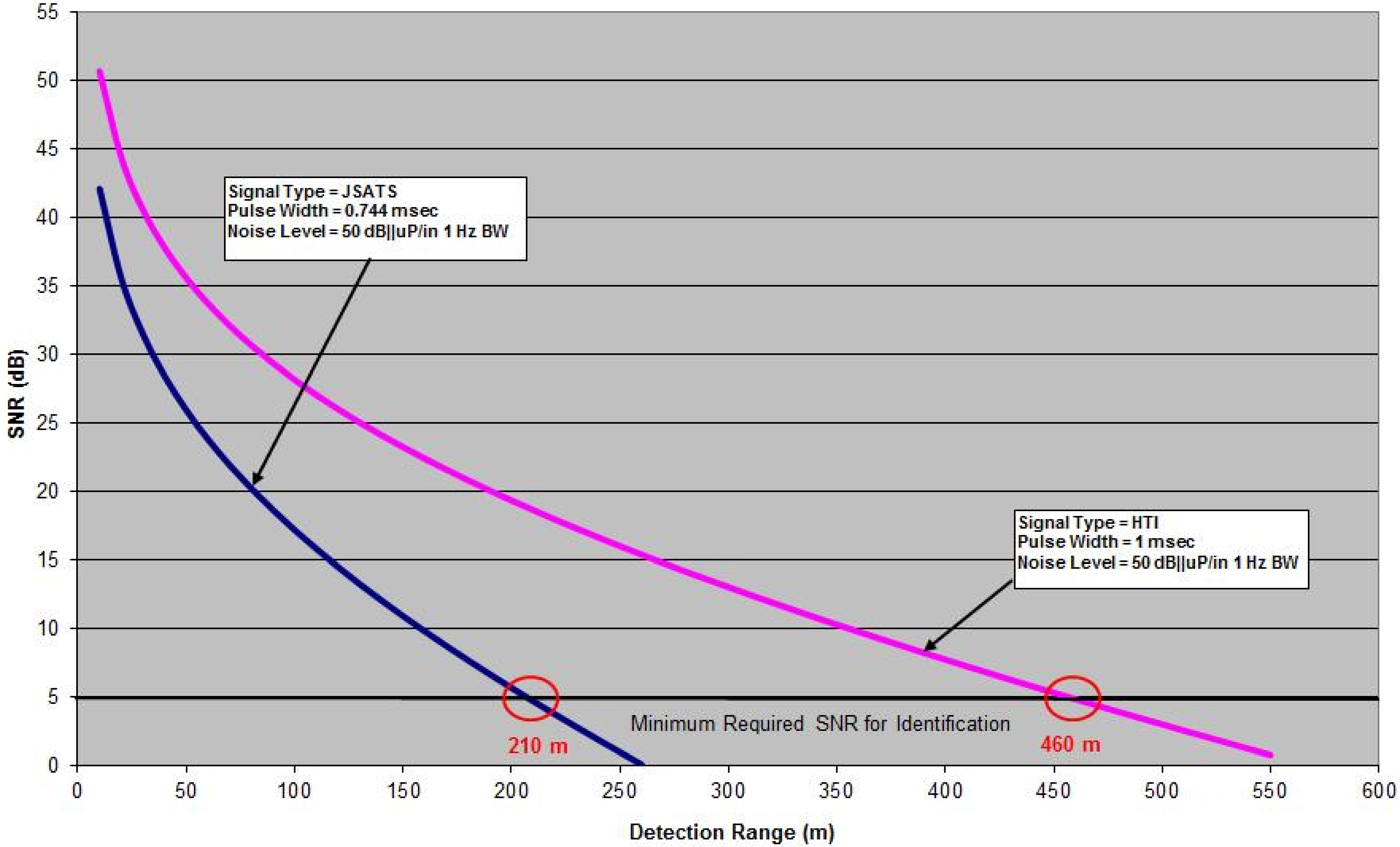
$$SNR = \frac{2E_s}{N_o} = \frac{2P_s T}{N_o}$$

Where

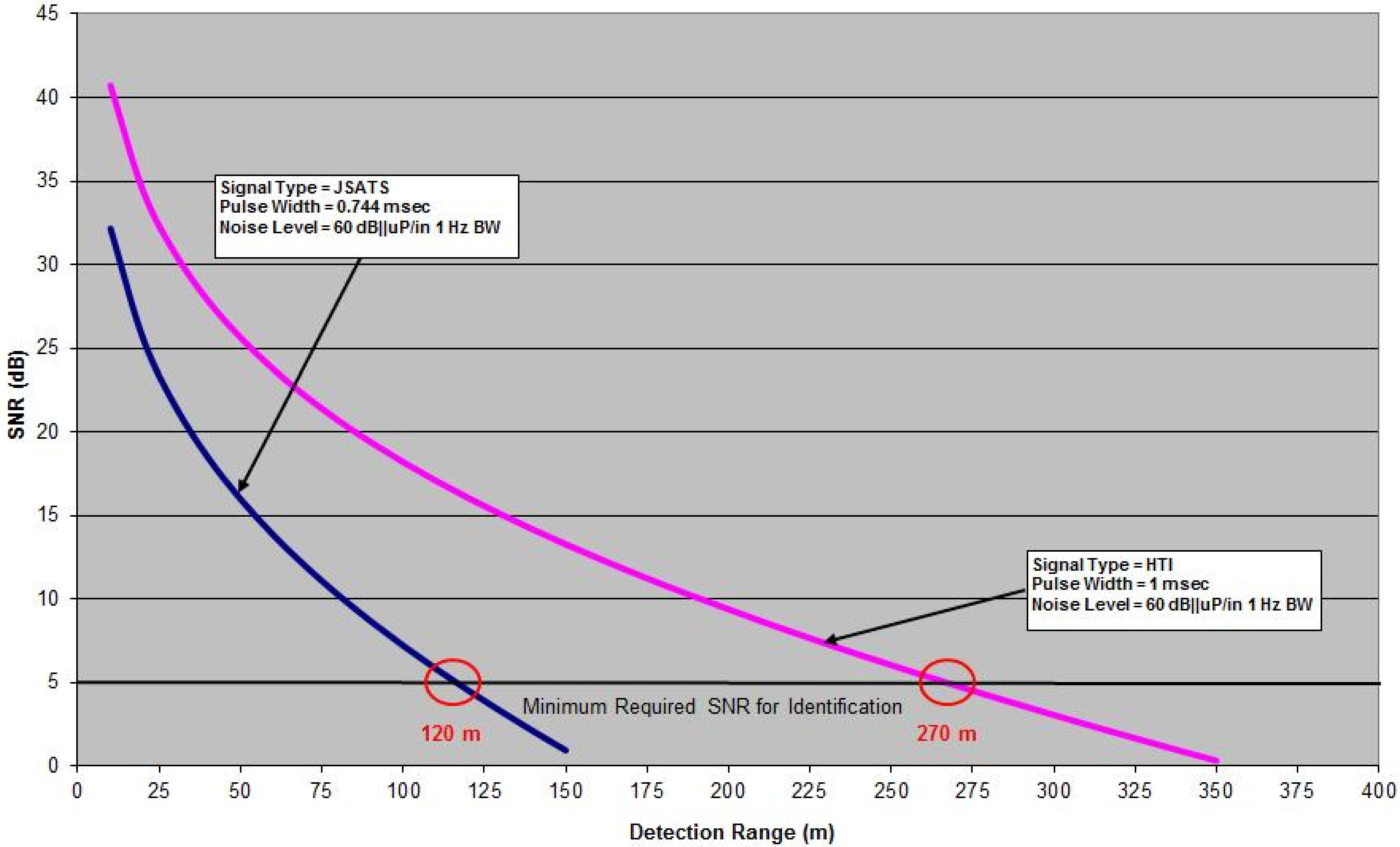
E_s is the energy in the received signal,
N_o is the acoustic noise spectral density,
P_s is the received acoustic power, and
T is the signal duration.

Analysis method similar to that described in Ehrenberg and Steig. 2009.

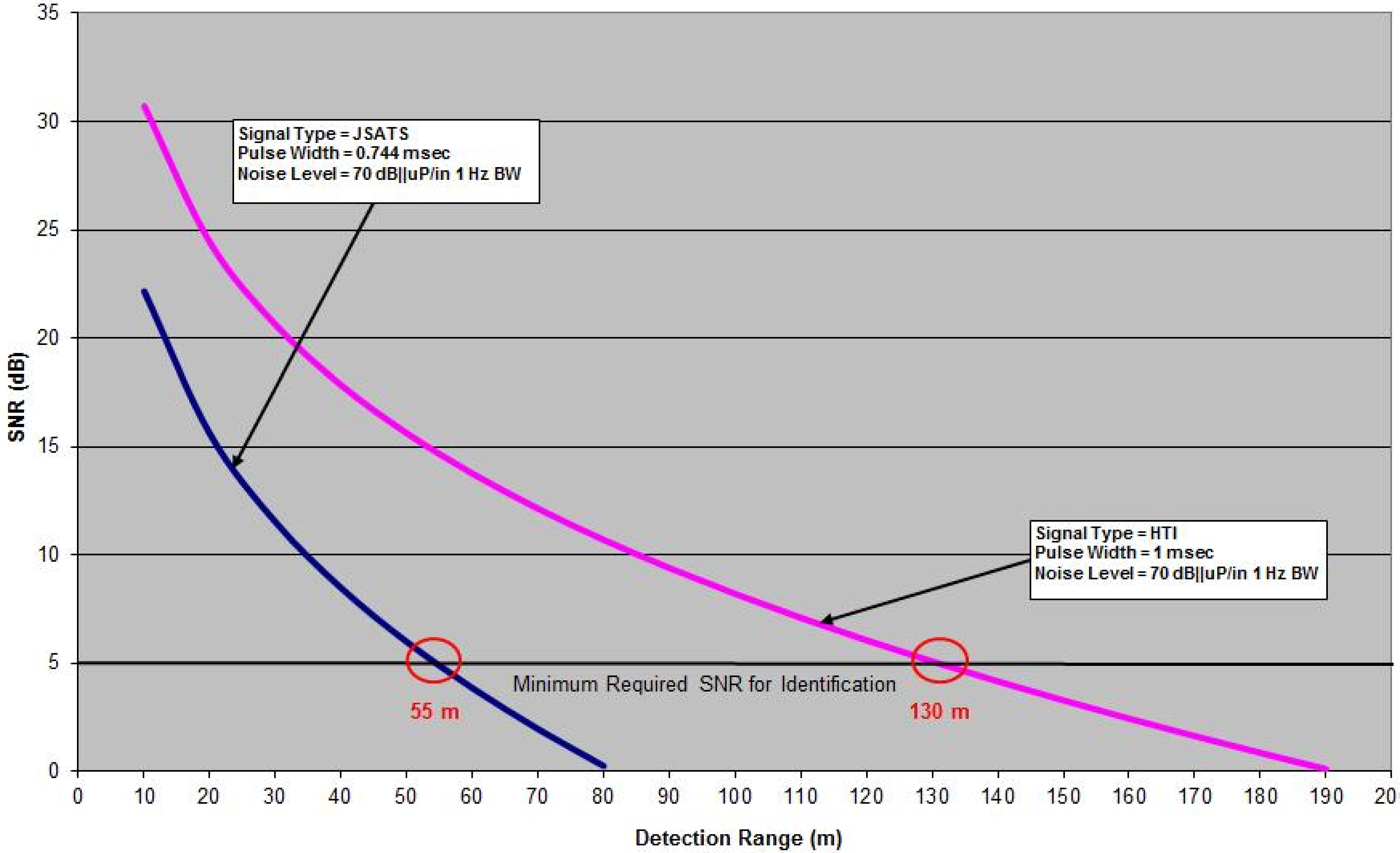
Comparison of SNR performance for signal encoding methods for a low noise environment



Comparison of SNR performance for signal encoding methods for a medium noise environment



Comparison of SNR performance for signal encoding methods for a high noise environment

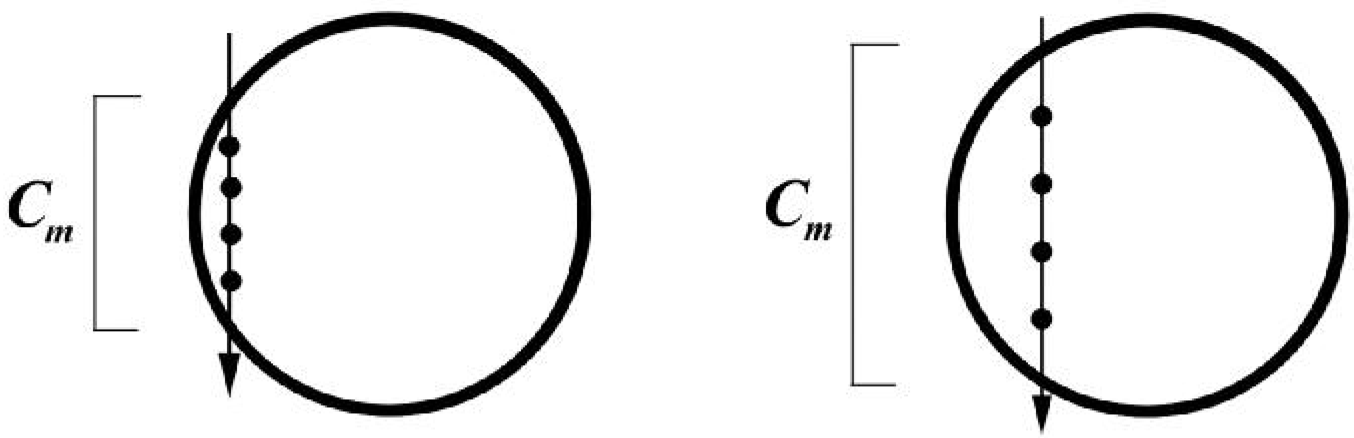


Definition of Minimum Chord Length

Minimum Distance Travelled Across the Detection Range

$$C_m = \frac{N_m V_t}{P_R}$$

C_m = minimum chord length across the detection circle in the direction of travel,
N_m = minimum number of detections to be classified as a valid detection,
V_t = tag velocity across the detection circle,
P_R = tag repetition rate.

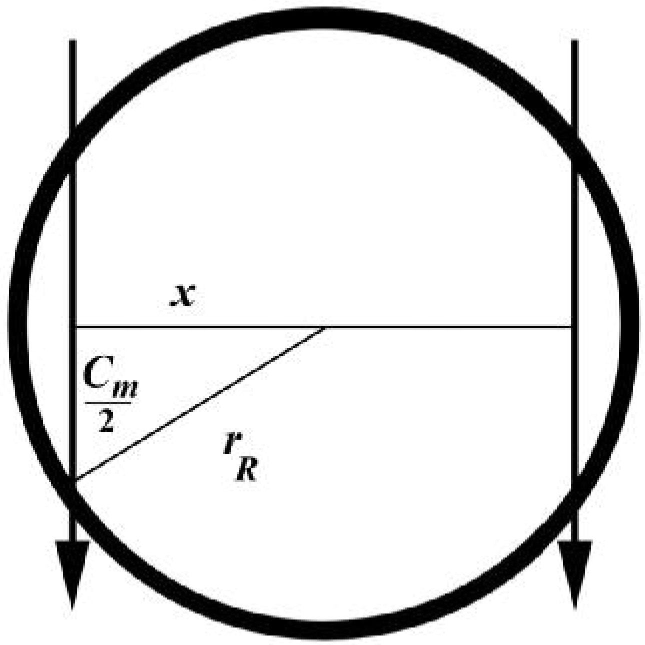


Definition of Effective Detection Range

Effective Detection Range

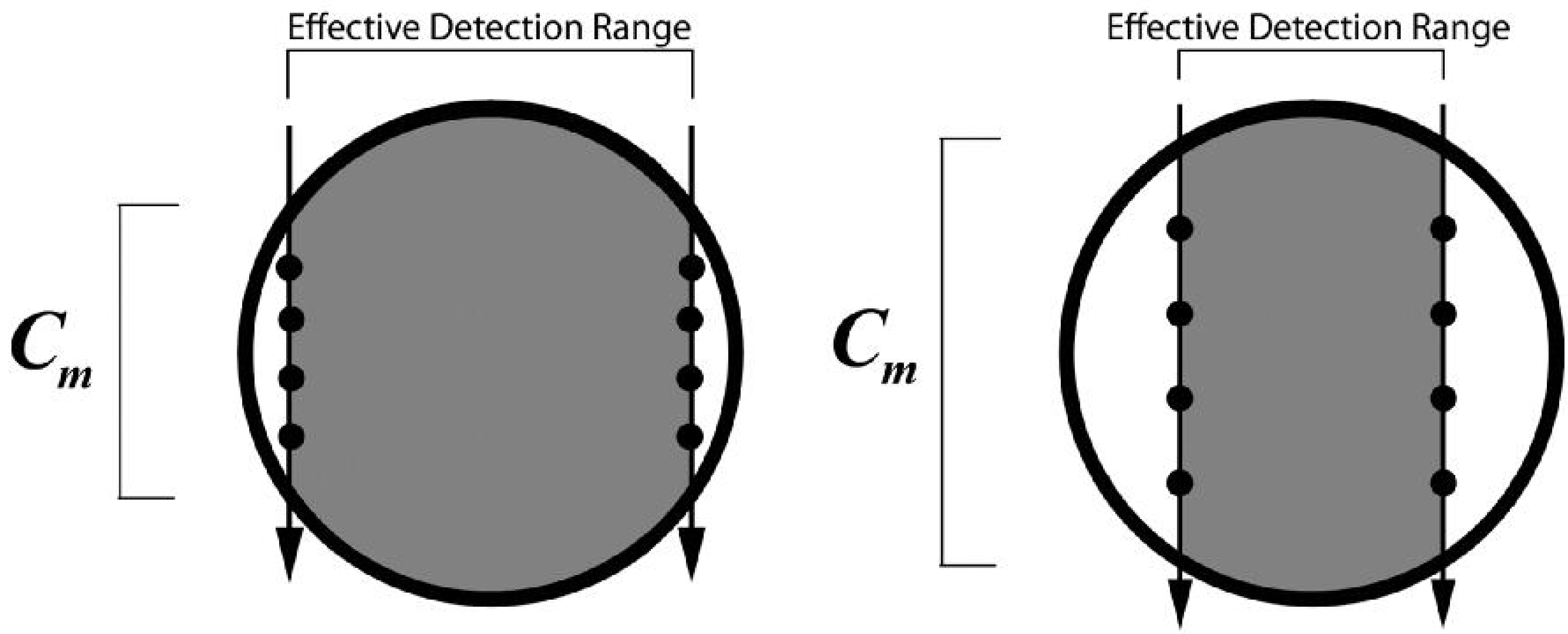
$$x_R = \sqrt{r_R^{\,2} - \left(\frac{C_m}{2}\right)^2}$$

$$E_{DR} = 2 * x_R$$



Example of Effective Detection Range

Effective Detection Range



Comparison of Effective Detection Range as a function of Water Velocity and Environmental Noise

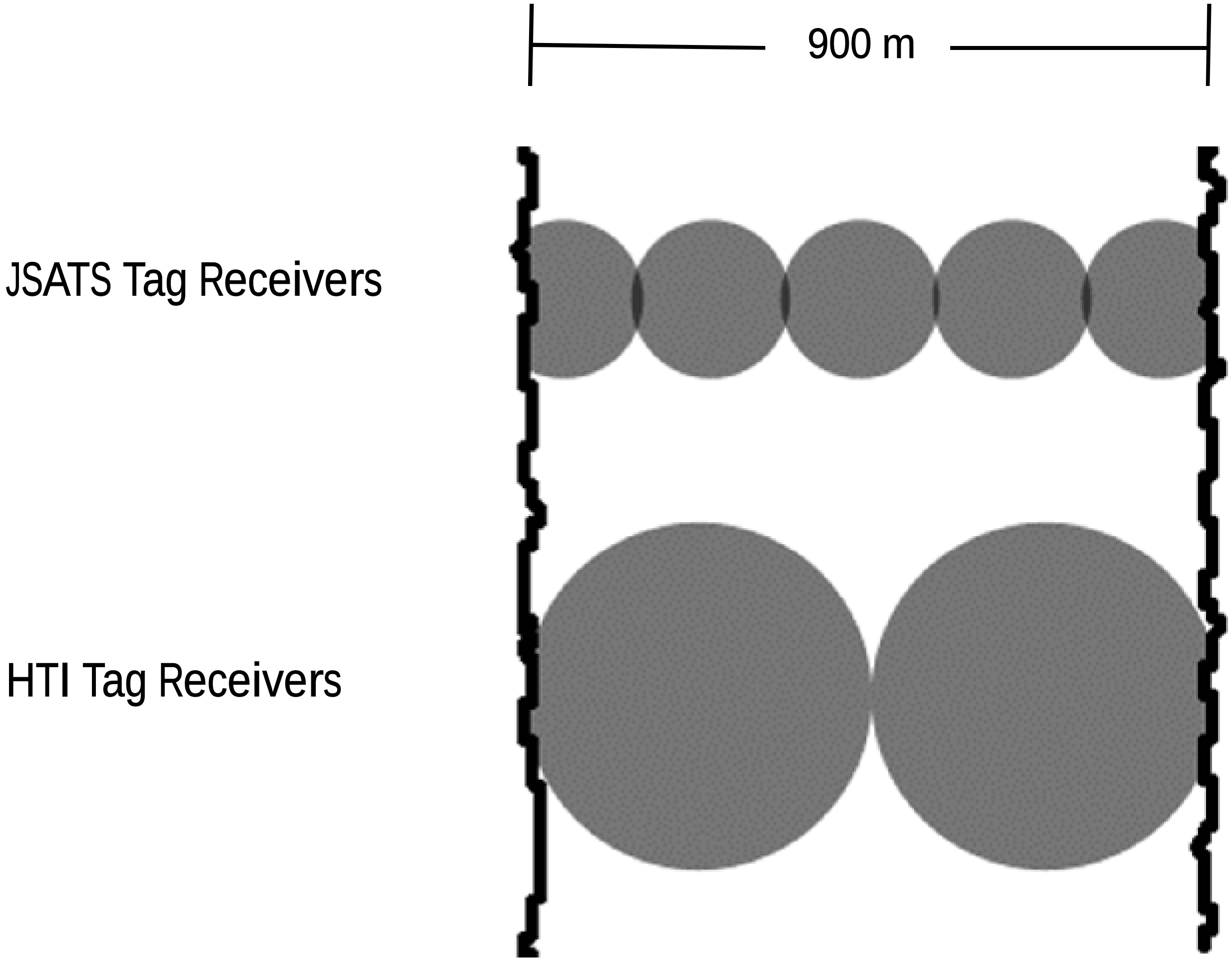
PRI-interval between Pulses (sec)	Detection Time (sec)	Water Velocity (m/sec)	Noise Level (dB||uPa/ 1 Hz BW)	JSATS Maximum Detection Range (m)	JSATS Effective Detection Range (m)	HTI Maximum Detection Range (m)	HTI Effective Detection Range (m)	Comments
3	12 to 15	1	50	210	209.66 *	460	459.76	Low water velocity, low noise environment
3	12 to 15	3	50	210	206.89 *	460	457.79	High water velocity, low noise environment
3	12 to 15	1	60	120	119.4 *	270	269.58	Low water velocity, medium noise environment
3	12 to 15	3	60	120	114.47 *	270	266.22	High water velocity, medium noise environment
3	12 to 15	1	70	55	53.67 *	130	129.13	Low water velocity, high noise environment
3	12 to 15	3	70	55	41.58 *	130	121.96	High water velocity, high noise environment

Detection ranges 2.2 to 2.9 times greater detection ranges.

* Assumes detection criteria is 4 consecutive detections as opposed to the JSATS stated criteria of "four valid detections in 60 seconds and the spacing between signals has to equal the expected PRI to be kept as a valid detection."

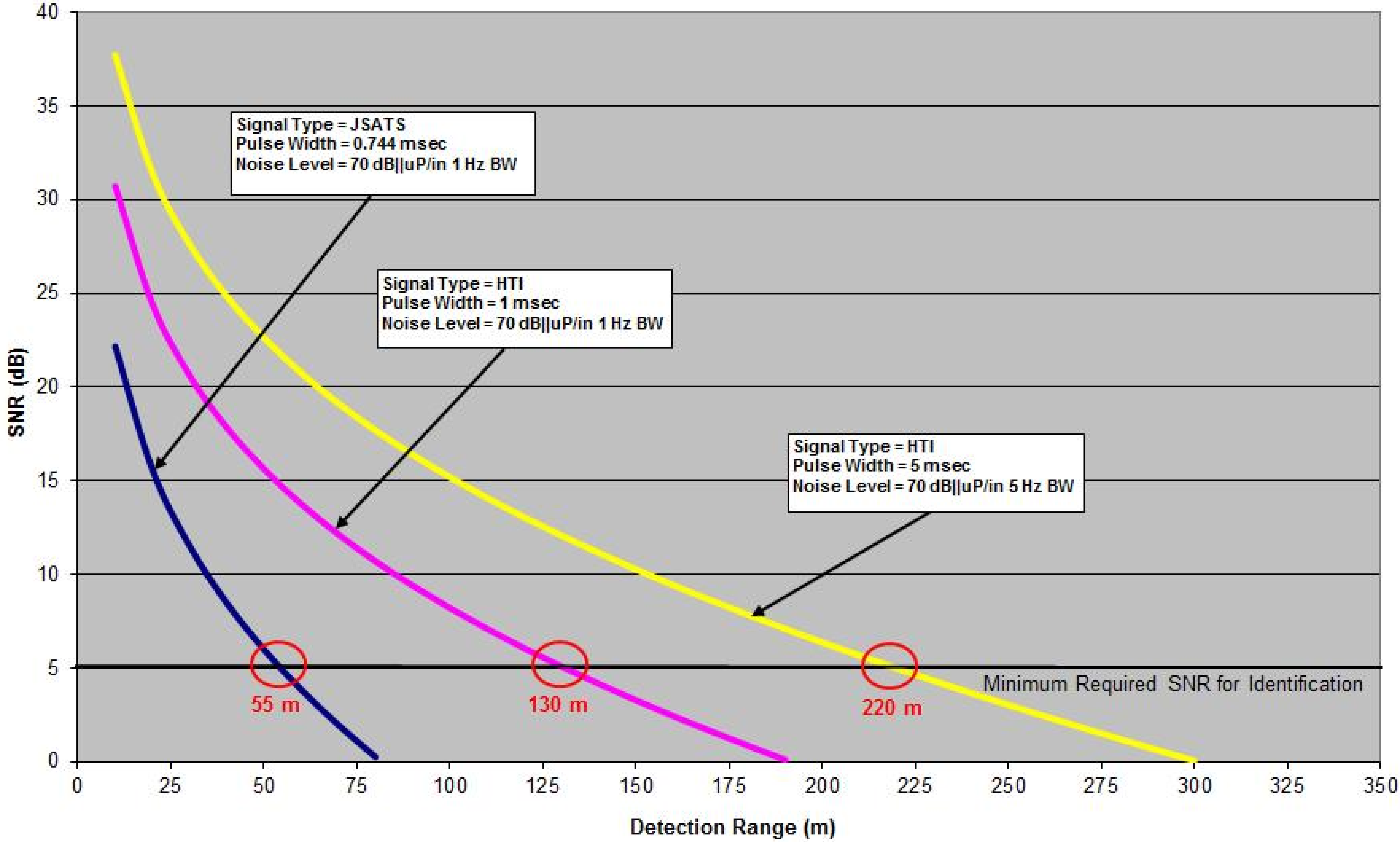
"Filtering Acoustic Signal Transmissions (FAST) Program" downloaded from http://www.cbr.washington.edu/analysis/apps/fast and in McMichael et. al. 2010.

Example of Plan View Detection Volumes



Low Noise Detection Range Comparison

Comparison of SNR performance for signal encoding methods for a high noise environment with different pulse width signals



Comparison of Effective Detection Range as a function of Water Velocity and Environmental Noise with Increased Pulse Width

PRI-interval between Pulses (sec)	Detection Time (sec)	Water Velocity (m/sec)	Noise Level (dB||uPa/ 1 Hz BW)	JSATS Maximum Detection Range (m)	JSATS Effective Detection Range (m)	HTI Maximum Detection Range (m)	HTI Effective Detection Range (m)	Comments
3	15	1	50	210	209.66 *	460	459.76	Low water velocity, low noise environment
3	15	3	50	210	206.89 *	460	457.79	High water velocity, low noise environment
3	15	1	60	120	119.4 *	270	269.58	Low water velocity, medium noise environment
3	15	3	60	120	114.47 *	270	266.22	High water velocity, medium noise environment
3	15	1	70	55	53.67 *	130	129.13	Low water velocity, high noise environment
3	15	3	70	55	41.58 *	130	121.96	High water velocity, high noise environment
3	15	3	70	55	41.58 *	220	215.35	High water velocity, high noise environment

Detection ranges up to 5.2 times greater detection ranges.

* Assumes detection criteria is 4 consecutive detections as opposed to the JSATS stated criteria of "four valid detections in 60 seconds and the spacing between signals has to equal the expected PRI to be kept as a valid detection."

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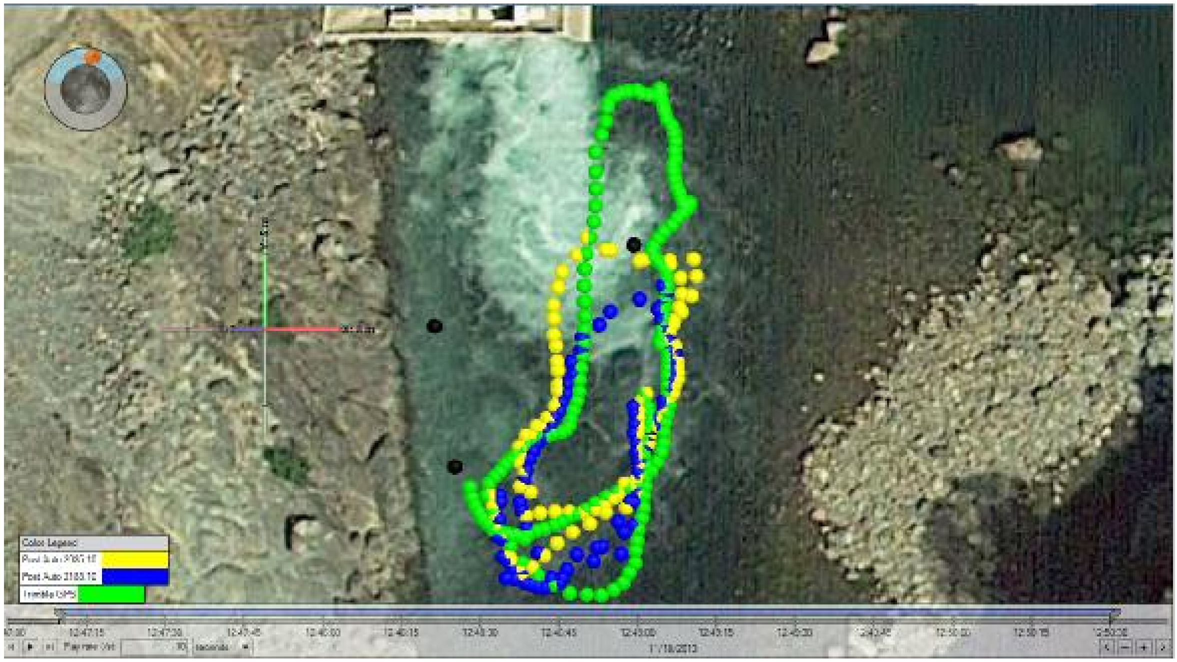
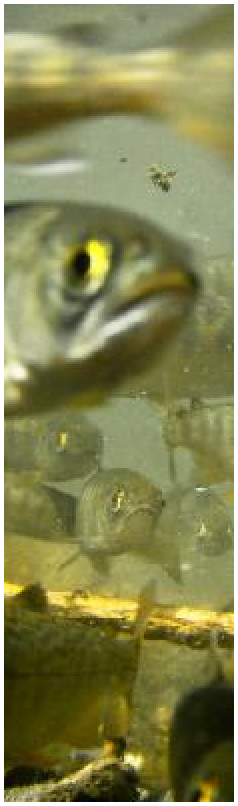
2D Tracking Feasibility at Narrows 2 Powerhouse (Yuba River)



Presentation Summary and Conclusions

- **Comparisons of JSATS and HTI acoustic tags were made for the:**
  - **Signal Type**
  - **Operating Frequency**
  - **Source Level**
  - **Pulse Repetition Rate**
  - **Signal Absorption**
- **With increasing water velocities, there was a moderate reduction in the effective detection ranges. Depending on detection criteria, there could be large reductions in the effective detection ranges.**
- **Increasing noise caused a large decrease in the effective detection ranges.**
- **The effective detection ranges were 2.2 to 2.9 times greater for the HTI acoustic tags as compared to the JSATS tags.**
- **The flexibility to increase the pulse width of the HTI tags resulted in a large increase in the effective detection ranges (5.2 times).**
- **In all comparisons, the estimated detection ranges were greater for the HTI acoustic tags as compared to the JSATS tags.**



Thank you.

Questions?

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