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JSATS Tag Development for Juvenile Salmon, Sturgeon, Eels, and Lamprey

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Summary

- Developed a **new tag** that can be injected instead of surgically implanted. The updated 2014 version has a tag life of > 100 days at 3-s ping rate. Fish tagging threshold is still being evaluated.
- Developed a long-life juvenile **sturgeon tag**, that may be useful for larger fish including adult lamprey and salmon.
- Developing tag for **juvenile lamprey and eels**.
- Demonstrated the performance of JSATS in a **fishway** with 100% detection probability.
- A recent publication indicates that **marine mammals** may use signals from acoustic tags to locate fish. This issue will only affect tags of < 200 kHz frequency. It does not apply to JSATS because JSATS' operating frequency is 417 kHz.

Juvenile Salmon Acoustic Telemetry System (JSATS) Components

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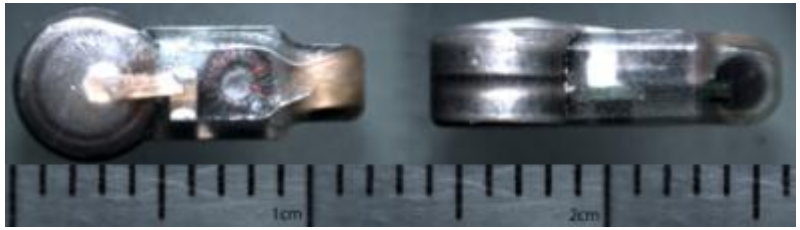
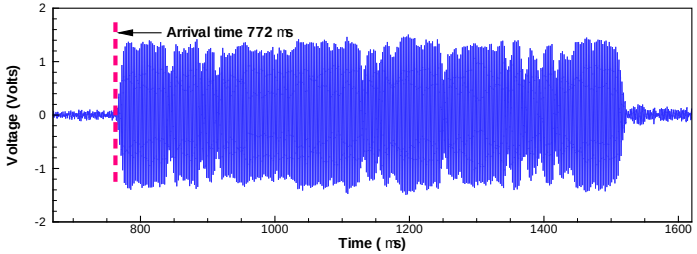
- The JSATS consists of acoustic transmitters, receivers, and data management and processing software.

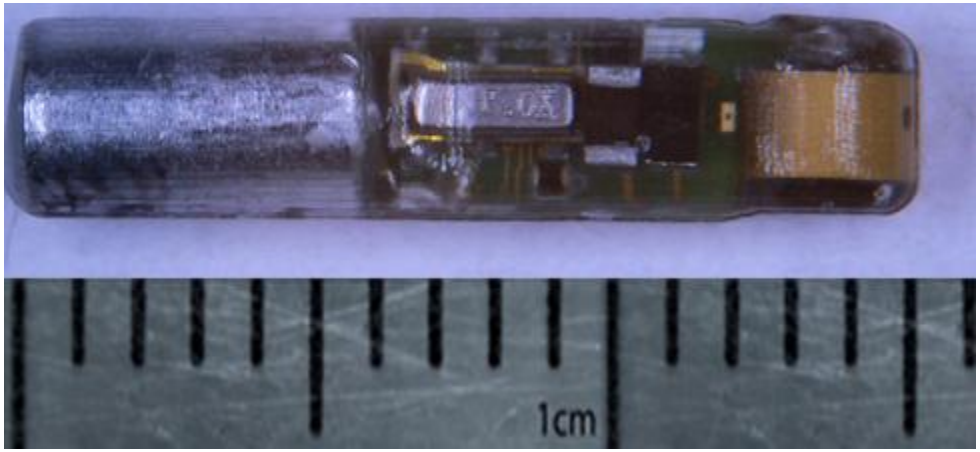




(a)

(b)

2013 Prototype



- Dimension: 15 mm x 3.3 mm
- Dry Weight: 216 mg
- Wet Weight: 105 mg
- Volume: 0.111 mL
- Source Level:
  - 157 dB at zero deg
  - 155 dB average -90 to 90 deg
- Configurable pulse rate interval, source level, tag code.
- Optional temperature, alternating, and hibernation mode.
- Tag Life: 20 days at 3-s pulse rate interval.

2013 Field Evaluation: Study Design

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- Manufactured 1000 tags in-house.
- Injected 682 fish with the new tag at LMN.
- Single release location over June 21 to July 1 at Central Ferry (rkm 655).
- Control group: 1035 Performance Standards Evaluation study fish implanted with regular tags released during the same period.
- Handled fish from both groups same way except for implantation and tag design.

Detection Probabilities Comparison: No Significant Difference

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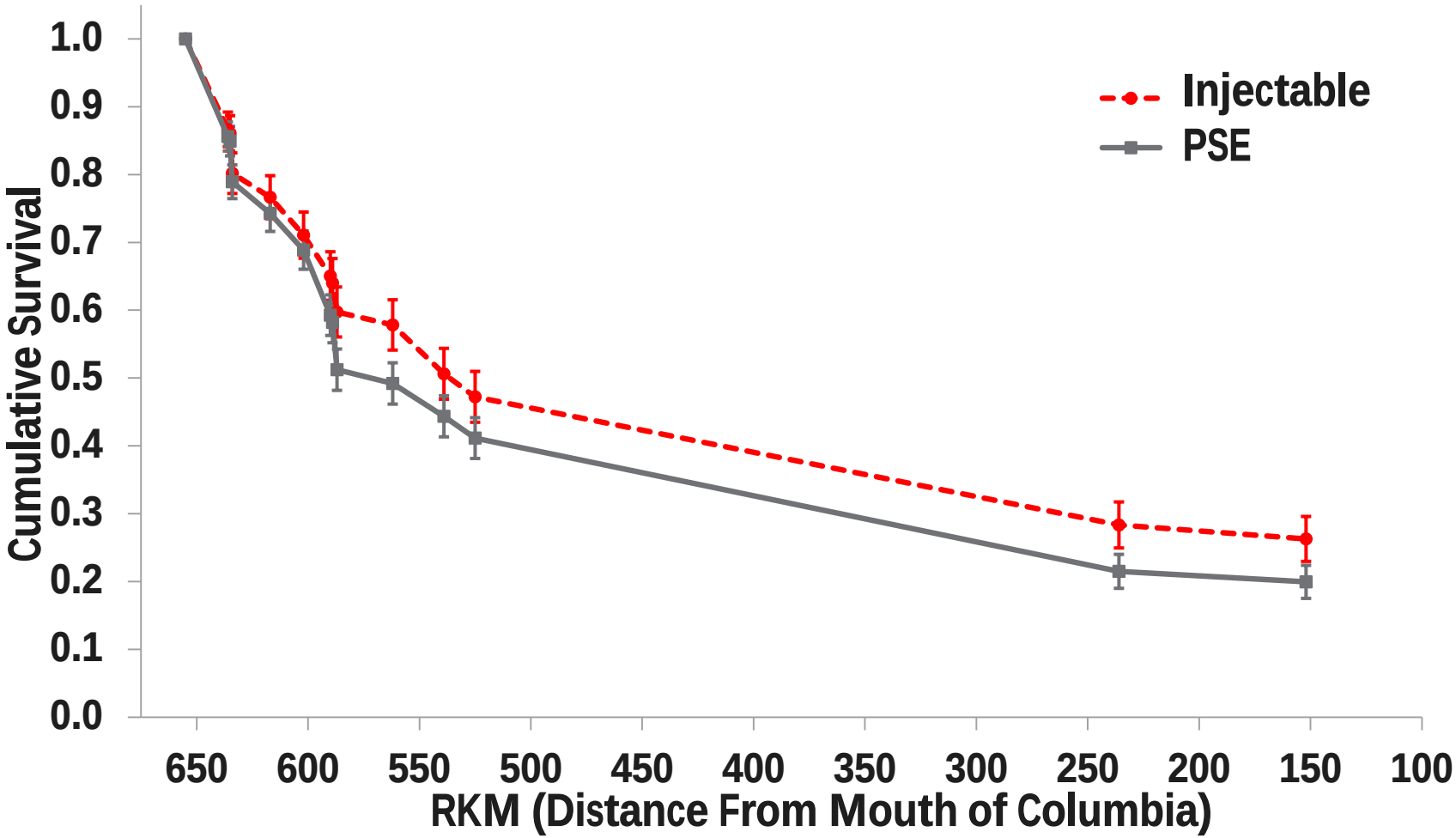
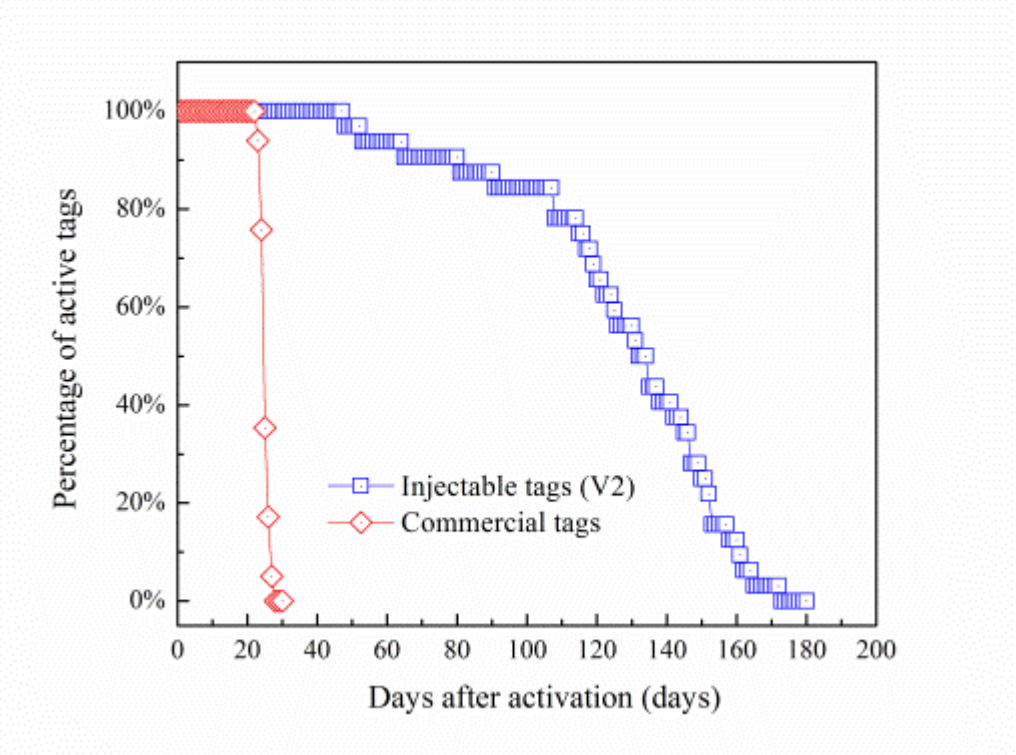
RKM	Array Type	Injectable Tag	PSE Tag
636	Autonomous	0.9983	0.9977
635	Cabled - LGS	0.9982	0.9988
634	Autonomous	1	0.9987
617	Autonomous	1	1
602	Autonomous	1	1
590	Autonomous	1	1
589	Cabled – LMN	1	1
587	Autonomous	1	1
562	Autonomous	1	1
539	Autonomous	1	1
525	Autonomous	1	0.9955
236	Autonomous	1	1
152	Autonomous	0.9941	0.9951
126	Autonomous	0.9548	1

Single Release Cumulative Survival Without Tag Life Correction



2014 Prototype

- Same size as 2013 prototype.
- Same features except that source level is not configurable.
- Longer tag life: Average > 100 days at 3-s pulse rate interval.
- Possibility: Shorter injectable tag with a tag of 30-50 days for smaller juveniles in Willamette River, Snake River, and estuary?



FY13 Tag Effects: Comparison of Implantation Using an Incision vs. Injection

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- Determined that wound area is much smaller when the tag(s) were implanted via an incision compared to an injection – all methods without sutures for fish < 95 mm
- Determined that tag retention was higher when the tag(s) were implanted via an incision compared to an injection

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A comparison of implantation methods for large PIT tags or injectable acoustic transmitters in juvenile Chinook salmon

Katrina V. Cook[a], Richard S. Brown[a,*], Z. Daniel Deng[b], Ryan S. Klett[a], Huidong Li[b], Adam G. Seaburg[c], M. Brad Eppard[d]

FY14 Swimming Performance Evaluation

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- Objectives
  - Determine differences in critical swimming speeds (Ucrit)
    - AT vs. untagged control
    - AT+PIT vs. untagged control
    - Determine if there is a size threshold
- Methods
  - Used respirometers
  - N = 166 fish
  - Fork length: 75 to 104 mm; Mass: 5 to 15 g
  - Spline regression
- Results
  - No significant difference for AT vs. untagged control for fish > 80 mm
  - No significant threshold for AT+PIT vs. untagged controls

Future Steps to Identify Size Thresholds

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- Continue analysis of growth, wound area, and tag retention data comparing tagged to untagged fish implanted using an incision
- Threshold is likely to be closer to current 95 mm threshold.
- Challenges along a size range of fish to determine thresholds
  - Exposure to simulated turbine passage
    - Are tags expelled when the swim bladder expands with rapid decrease in pressure?
    - Currently ongoing
  - Predation trials
    - Are smaller tagged fish more susceptible to predation than controls?
    - Currently ongoing
  - Exposure to shear forces similar to turbine / spillway passage
    - Are tags expelled when smaller fish are bent and twisted?

Sturgeon Tag Specifications

- Dimension: 24.2 mm x 5.0 mm
- Dry Weight: 718 mg
- Wet Weight: 219 mg
- Volume: 419 mL
- Source Level:
  - 161 or 163 dB at zero deg
- Configurable pulse rate interval & tag code.
- Optional temperature, alternating, and hibernation mode.
- Tag Life: 365 days at 161 dB and 15-s pulse rate interval.

Sturgeon Tag Applications

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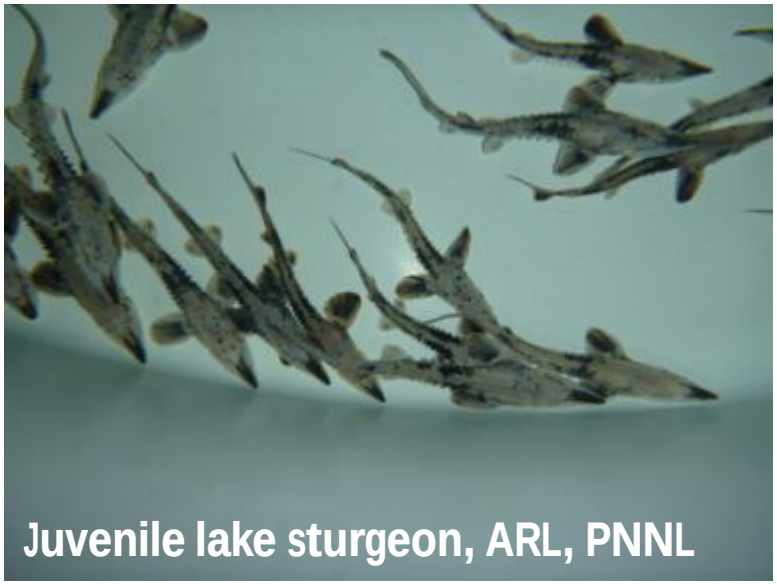
- Small juvenile (< 1 year old) sturgeon.
- Long term monitoring for adult fish such as adult lamprey.
- Noisy environment such as immediate tailrace due to higher source level.
- Mobile tracking due to longer detection range.


Juvenile lake sturgeon, ARL, PNNL

Juvenile white sturgeon, ARL, PNNL

Juvenile Lamprey/Eel Tag

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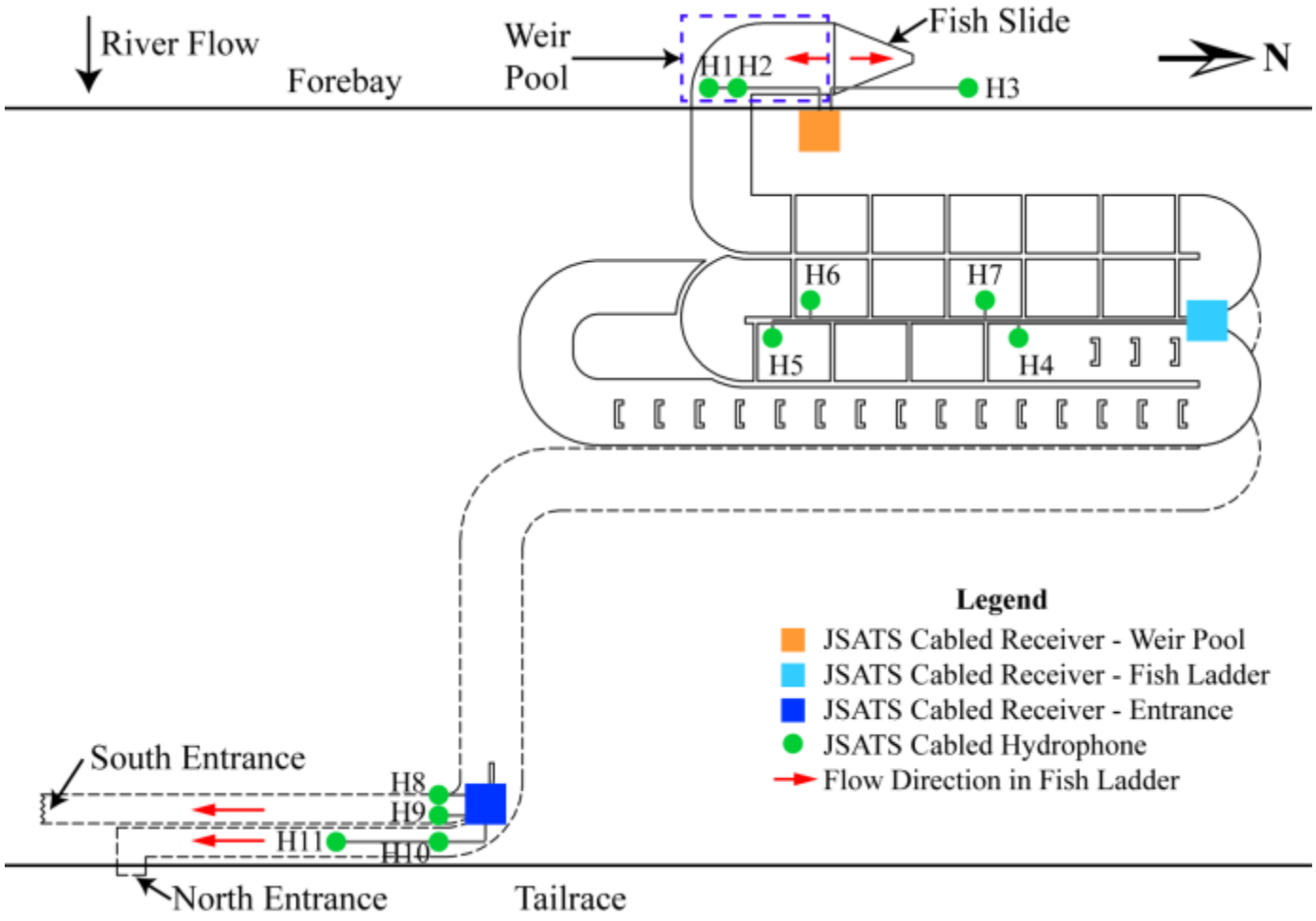
- Applications
  - Downstream passage of Pacific lamprey.
  - Upstream passage and fallback of American eel.
- Design and prototyping occurring in next two years.

Juvenile Pacific lamprey, ARL, PNNL

Juvenile American eels, ARL, PNNL

JSATS Deployment in a Fishway
Wanapum Dam



JSATS Performance in a Fishway Wanapum Dam

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- Detection efficiency from controlled field study.
  - Ratio of number of valid detections to expected number of transmissions.
    - 80% for most locations within fishway.
    - Nearly 100% in the fish ladder entrance when the tags were within 10 m of the hydrophones.
- Detection probability of tagged fish.
  - Ratio of detected numbers to expected number of fish.
    - 100% at all deployment locations.

Predation of Tagged Fish by Marine Mammals

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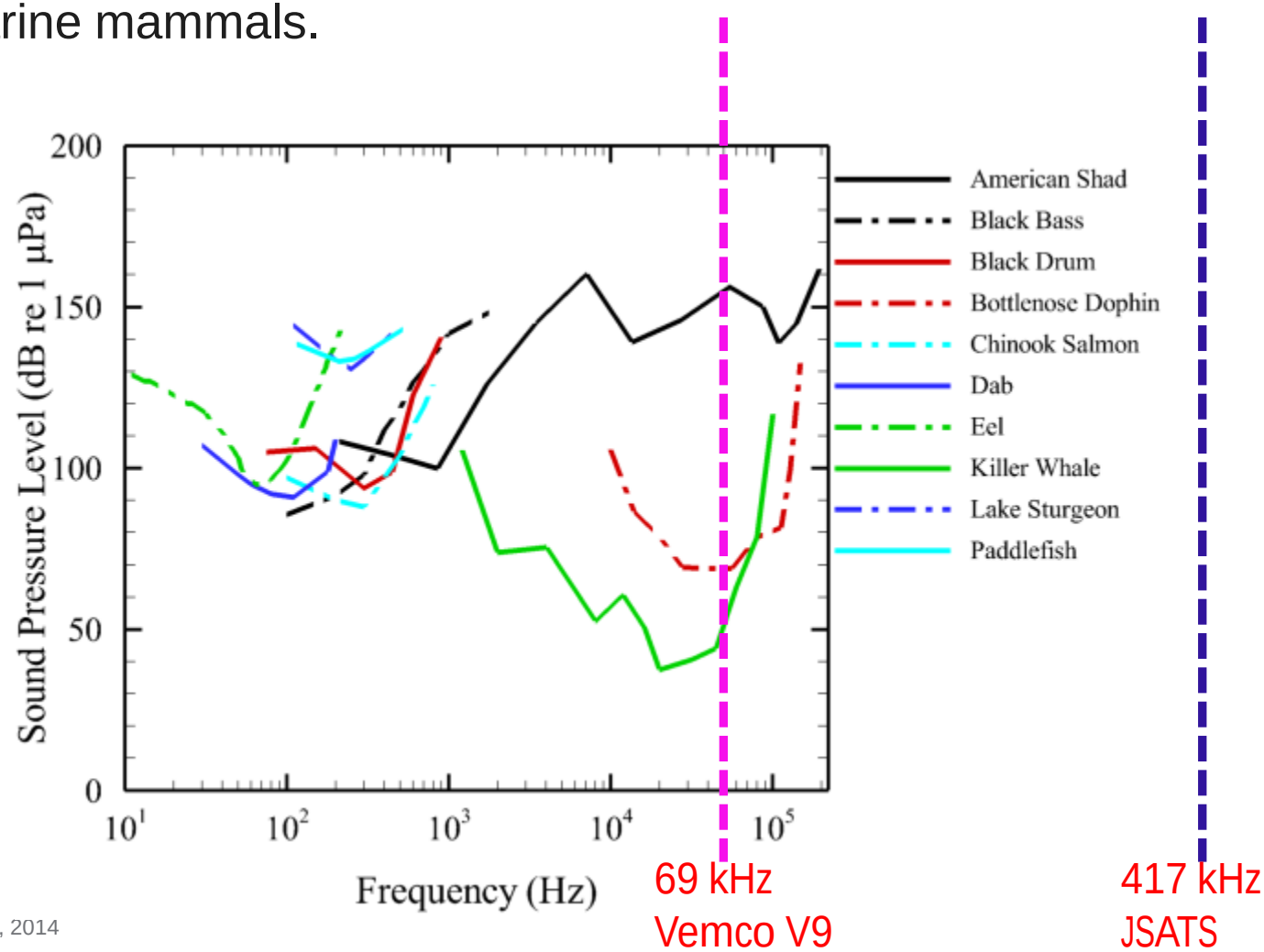
- Stansbury et al. (2014) reported that grey seals use signals from acoustic tags to locate fish.
  - 69 kHz Tag (Vemco V9)
  - Source level 151 dB SPL re 1 µPa
- Deng et al. (2014) also reported 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals.
  - Sub-harmonic sounds from 90 to 130 kHz
  - Potential hearing range is a few hundred meters depending on background

Stansbury et al. (2014) Grey seals use anthropogenic signals from acoustic tags to locate fish: evidence from a simulated foraging task. Proc. R. Soc. B 282: 20141595.

Deng et al. (2014) 200 kHz Commercial Sonar Systems Generate Lower Frequency Side Lobes Audible to Some Marine Mammals. PLoS ONE 9(4): e95315.

Implications for JSATS: Not an Issue

- Frequency and potential side lobe are outside the hearing range of marine mammals.



Summary and next steps

Tag Type	Dimension	Dry Weight (mg)	Source Level (dB)	Tag Life	Primary Application	Status
2013 Injectable	15 mm X 3 mm	216	155-157	20 days at 3-s PRI	Juvenile salmon	Completed
2014 Injectable	15 mm X 3 mm	216	155-156	> 100 days at 3-s PRI	Juvenile salmon	Completed
Sturgeon Tag	24 mm x 5 mm	718	161 or 163	365 days at 15-s	Juvenile sturgeon; adult lamprey; Noisy environment	Completed
Eel/lamprey	TBD	TBD	TBD	TBD	juvenile eel; juvenile lamprey	TBD
Shorter injectable	12 mm X 3 mm?	TBD	TBD	30-days at 3-s PRI?	Smaller juveniles in SR, CR, and WR	TBD

Summary and next steps

- Demonstrated the performance of JSATS in a **fishway** with 100% detection probability.
- A recent publication indicates that **marine mammals** may use signals from acoustic tags to locate fish. This issue will only affect tags of < 200 kHz frequency. It does not apply to JSATS because JSATS' operating frequency is 417 kHz.

Acknowledgements

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