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Ultrasound to guide American shad toward a spillway

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Caumartin, Jean; Lafleur, François; and Desrochers, Denis, "Ultrasound to guide American shad toward a spillway" (2018).

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Ultrasound to guide *American shad* toward a spillway

Jean Caumartin, Hydro-Québec – Environment

Denis Desrochers, Milieu inc.

François Lafleur, IREQ



American shad (Alosa sapidissima)

- ◆ Anadromous fish, found all along the East Coast of North America
- ◆ Reproduce between 1 and 7 times depending of latitude
- ◆ The St-Lawrence population:
 - Feeds in North Atlantic
 - Spends the winter in Bay of Fundy (NB)
 - In spring, (mid April) starts its spawning migration toward fresh water and the Montreal area

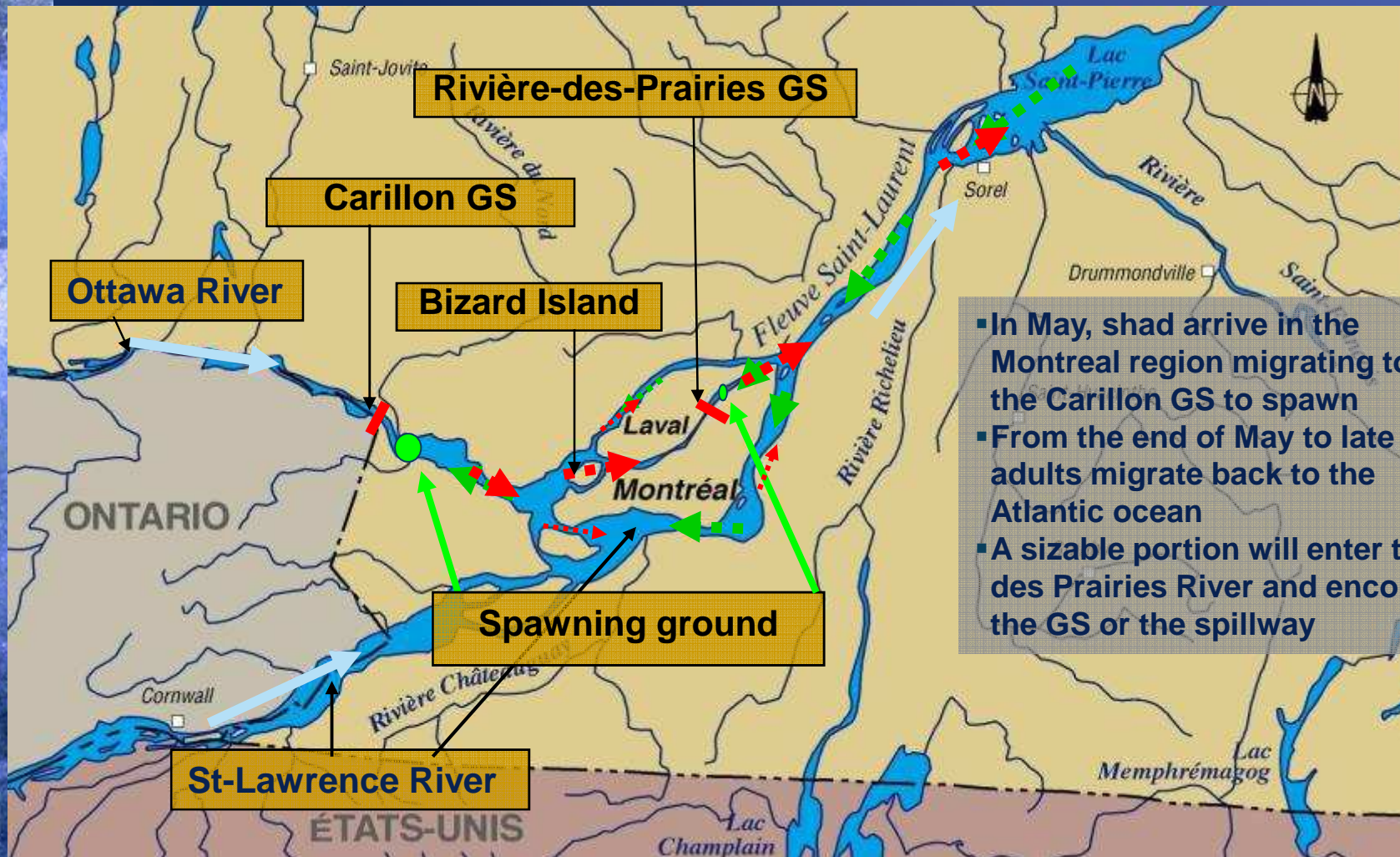
American shad - *Biology*



December 10-14, 2018

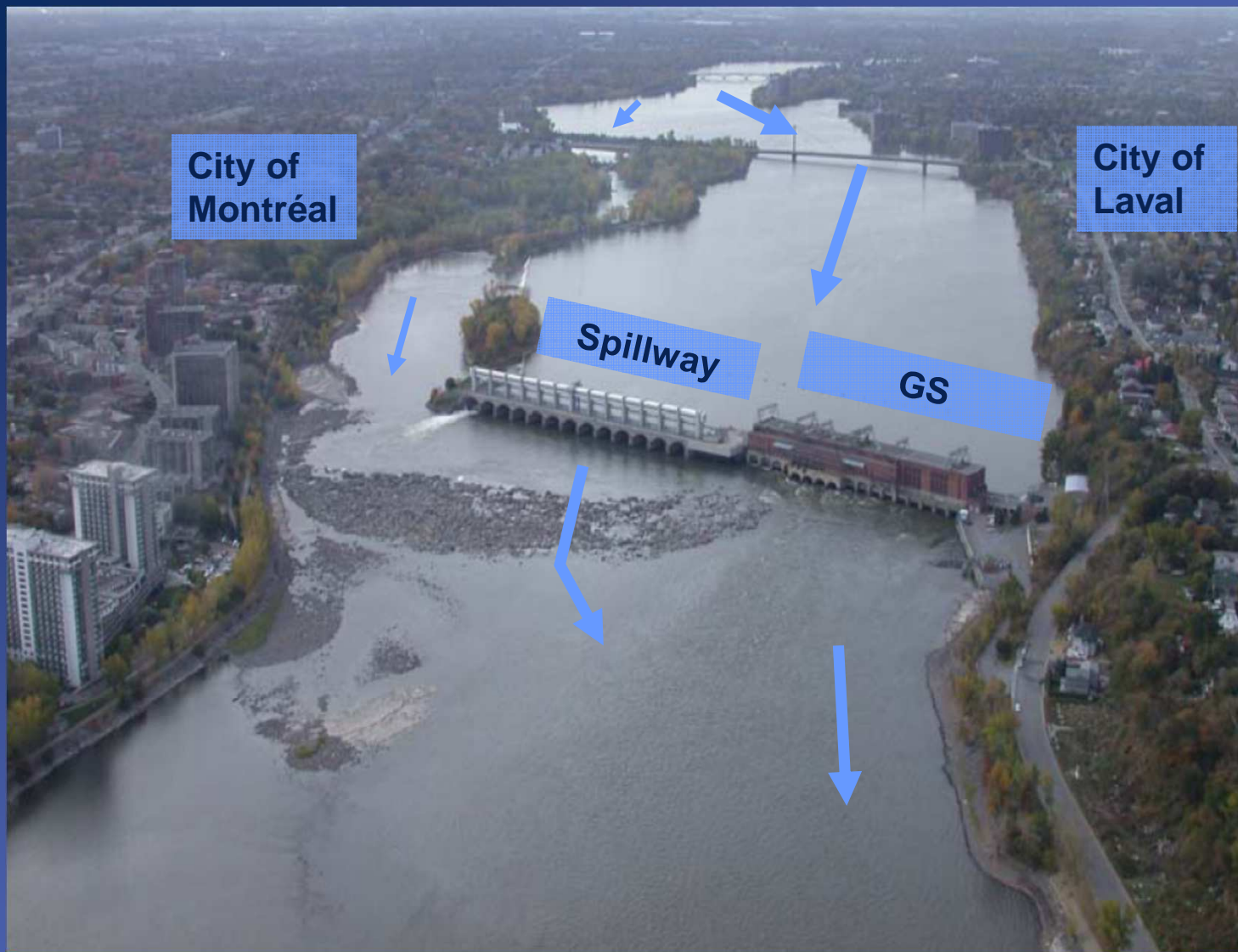
Albury Australia - Fish Passage 2018

American shad - Biology



- In May, shad arrive in the Montreal region migrating toward the Carillon GS to spawn
- From the end of May to late June, adults migrate back to the Atlantic ocean
- A sizable portion will enter the des Prairies River and encounter the GS or the spillway

Other issues

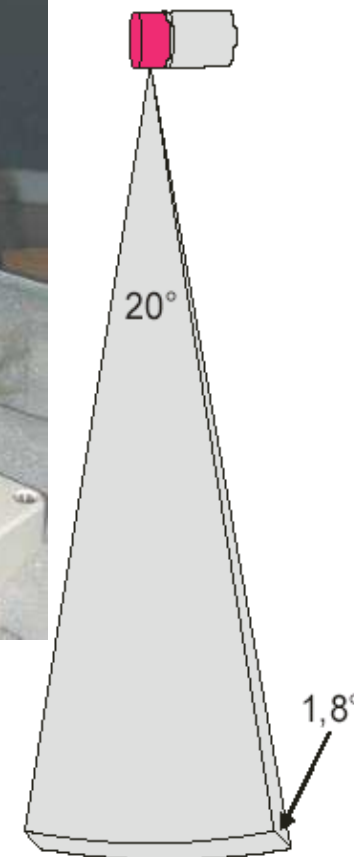
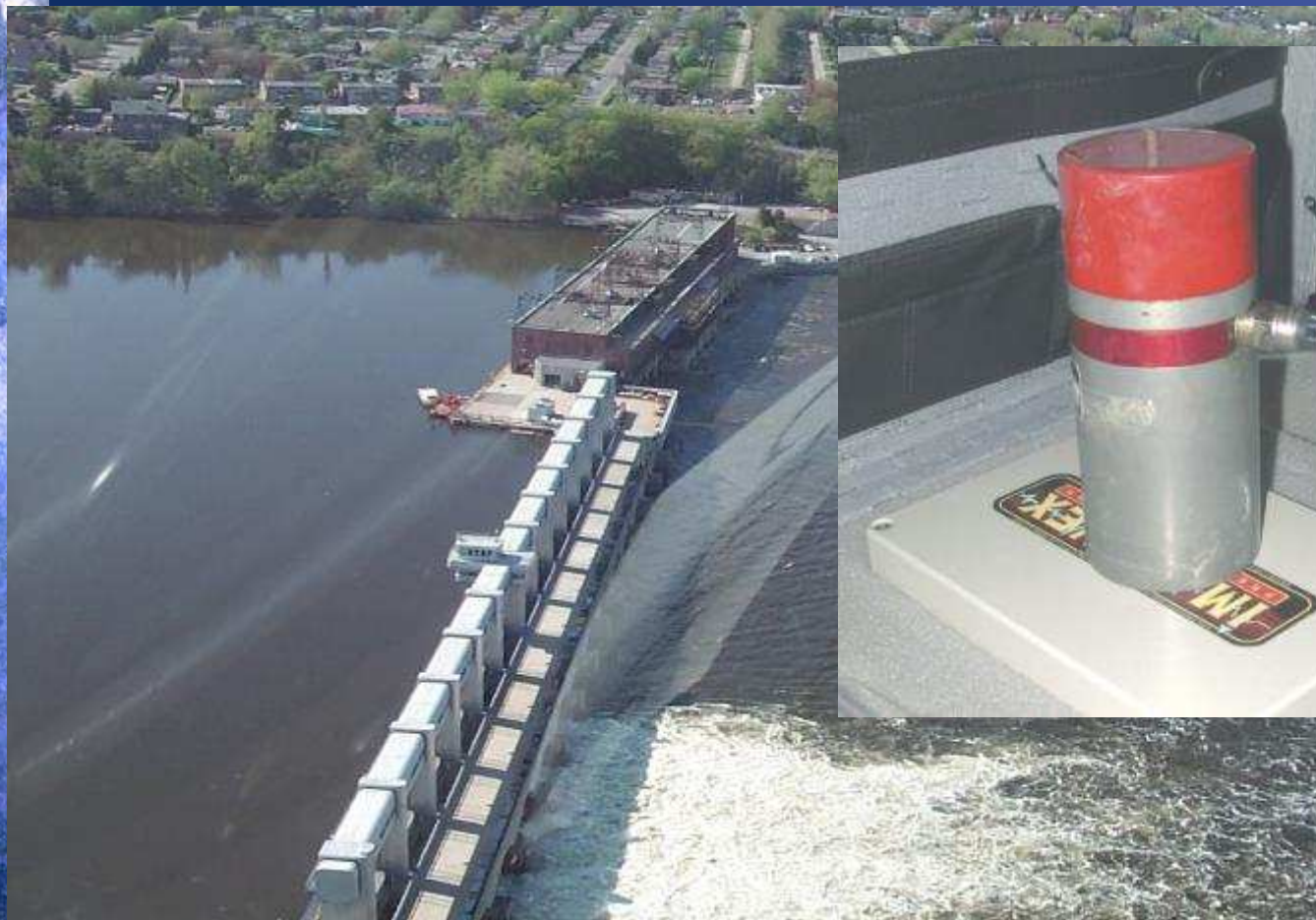


Other issues

- ◆ Largest Lake sturgeon spawning ground in Quebec's St-Lawrence River system
 - Spilled water is managed for lake sturgeon protection
 - Possibility to flush L. sturgeon larvae if hydraulic downstream of the GS is modified
- ◆ The arrival of post spawned downstream migrating A. shad conflicts with L. sturgeon protection

Solution – until 2005

- ◆ Spent adults detected by sonars

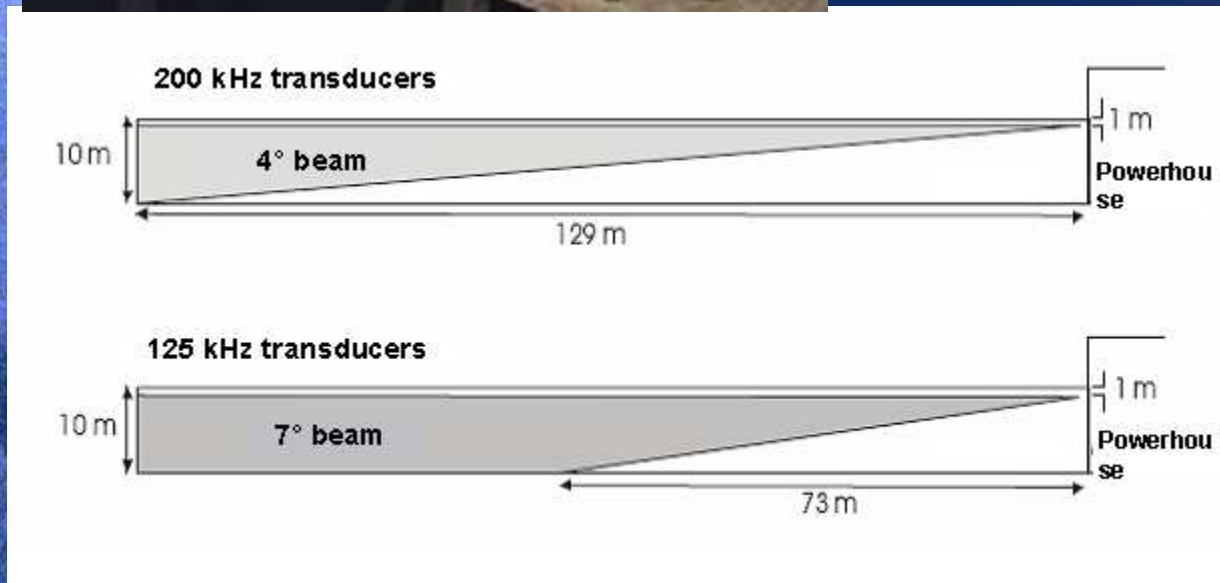


- ◆ Units shutdown and opening up spillway 1 h/d

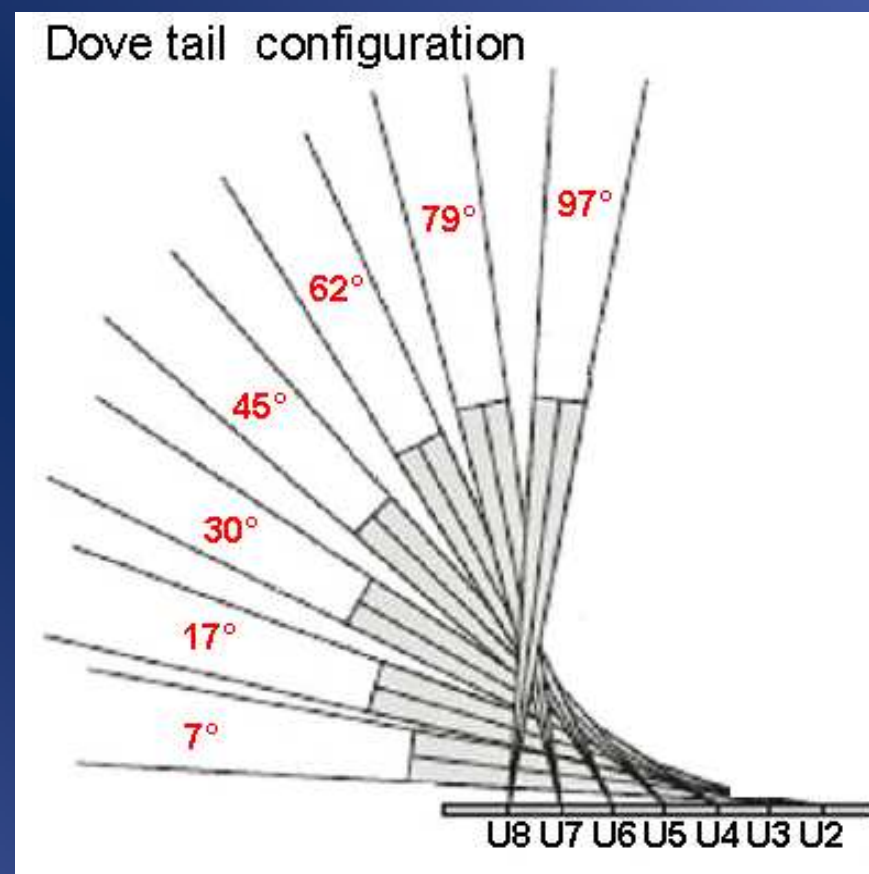
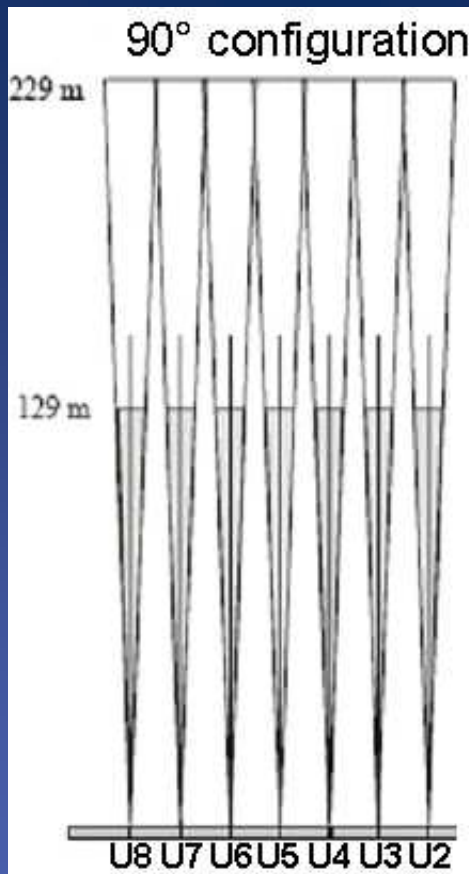
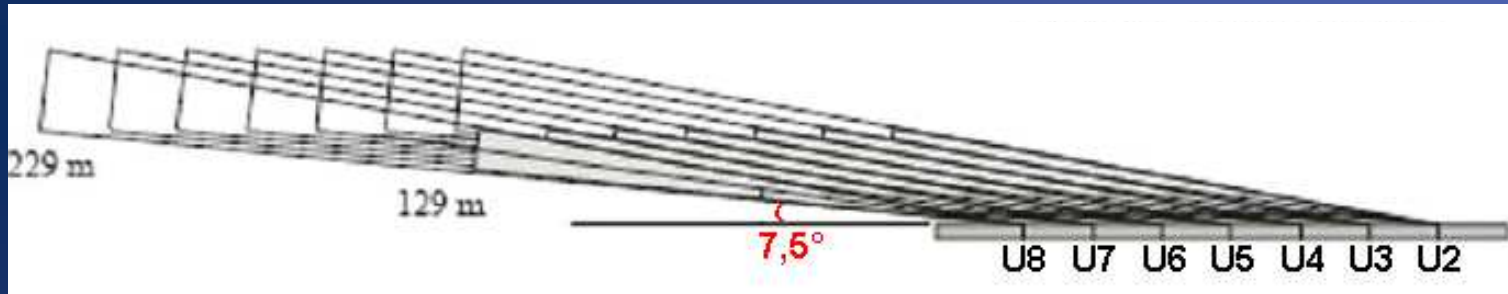
Problem / Solution

- ◆ How to protect of A. shad before dates set by Ministry of Environment for L. sturgeon (no gates maneuvers)?
- ◆ How to protect A. shad between the maneuvers (1 hr/d)?
- ◆ Is it possible to hold back A. shad during week-ends?
- ◆ Is it possible to keep some units in operation if enough flow?
- ◆ Solution:
 - Develop a procedure to evaluate the date at which L. sturgeon larvae are off the substrate
 - Develop a sound guidance system (ultrasound)
 - Shad reacts to these frequencies
 - Similar to the «clicks» made by hunting marine mammals
 - Possibility to keep turbines in no-charge state during the maneuvers or to keep some turbine on-line

Guidance system 2006 - 2010

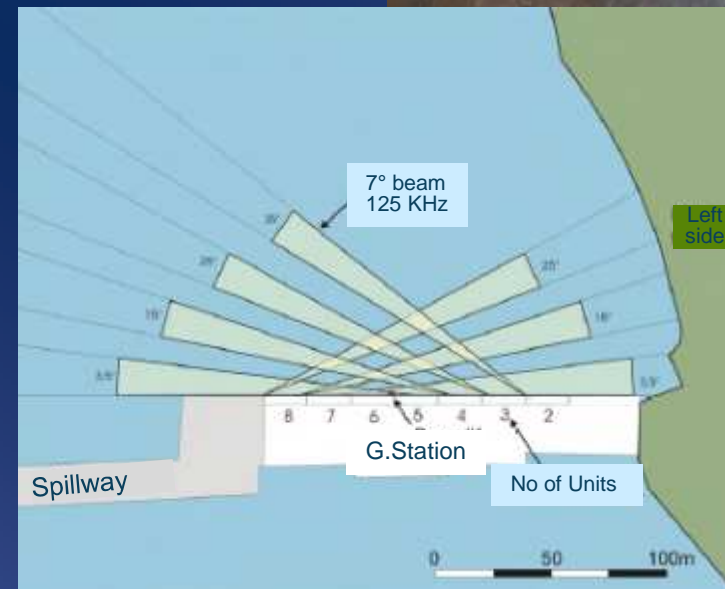
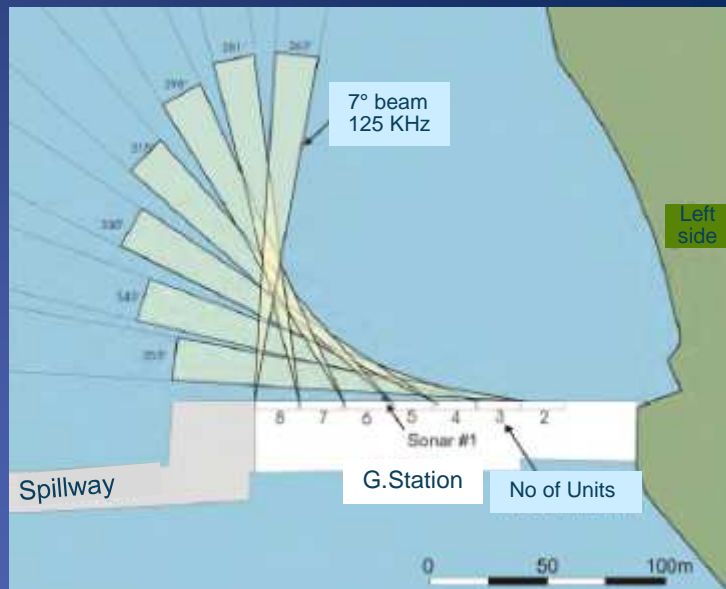


Guidance system 2006 - 2010



Guidance system 2006 - 2010

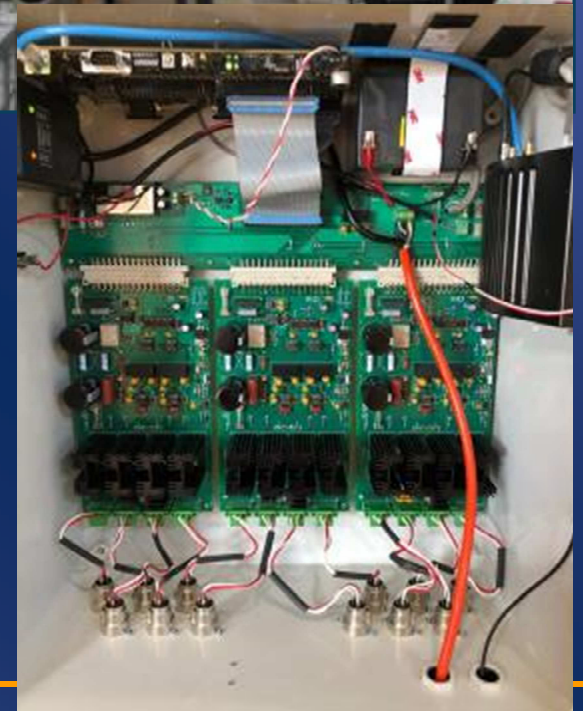
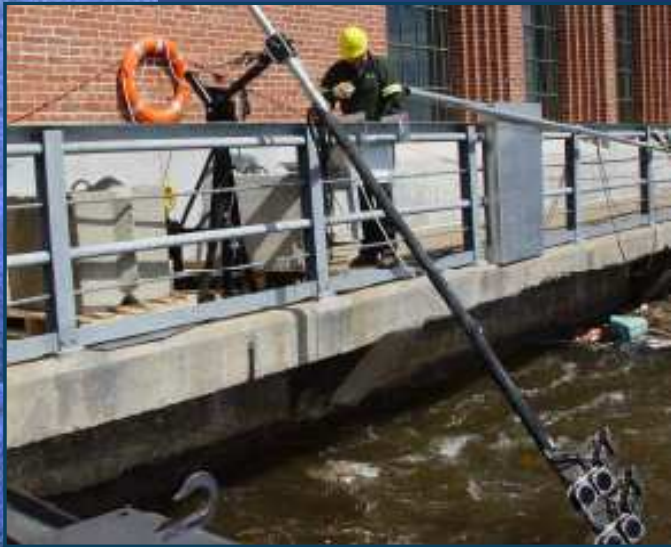
- ◆ Conclusion :
 - Frequency = 125 kHz
 - Pulse width = 3,8 ms
 - Duty cycle = 8 % (21 clicks / s)
 - Amplifier produces ± 220 dB, ref. $1\mu\text{Pa}$ at 1 m of the transducers



Guidance system 2009 - now

- ◆ Joined with Hydro-Quebec's Research Institute (IREQ) in 2009
- ◆ Objective:
 - Built a system to prevent shad to enter the des Prairies River (based on ultrasound)
- ◆ 2010 to 2016: improvements on the GS system made toward developing an autonomous shad guidance system:
 - Simulation and back calculation → threshold at which shad are reacting: 168 dB (ref. 1 μ Pa @ 1 m)
 - Re-designed amplifiers
 - Customized transducers
 - Only 2 poles in the water instead of 6: Easier debris clean-up operation at the GS

Guidance system at the GS

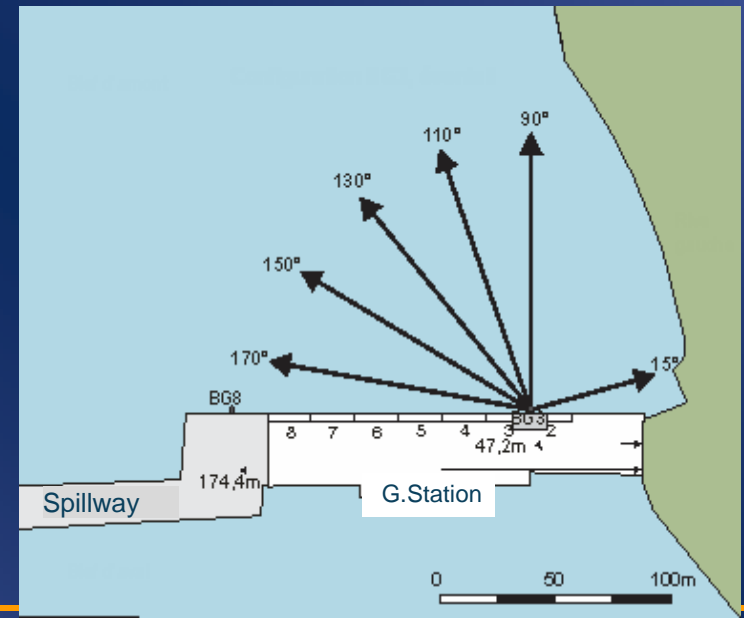
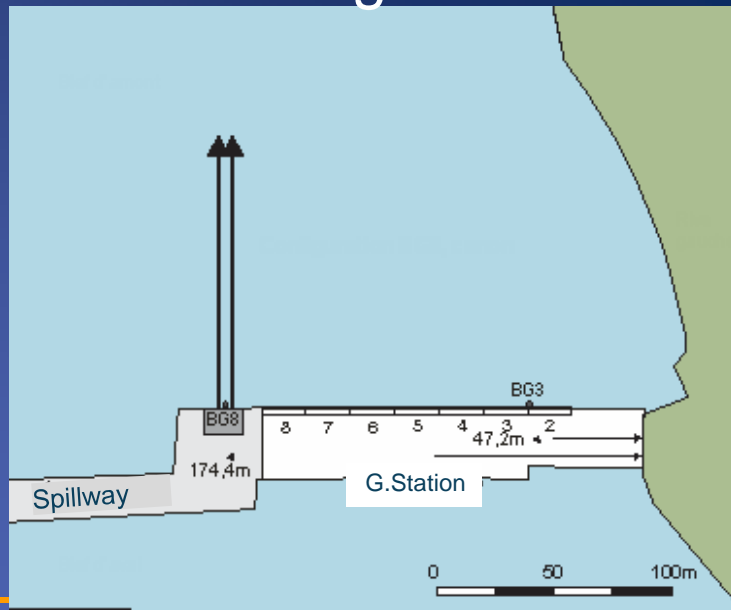


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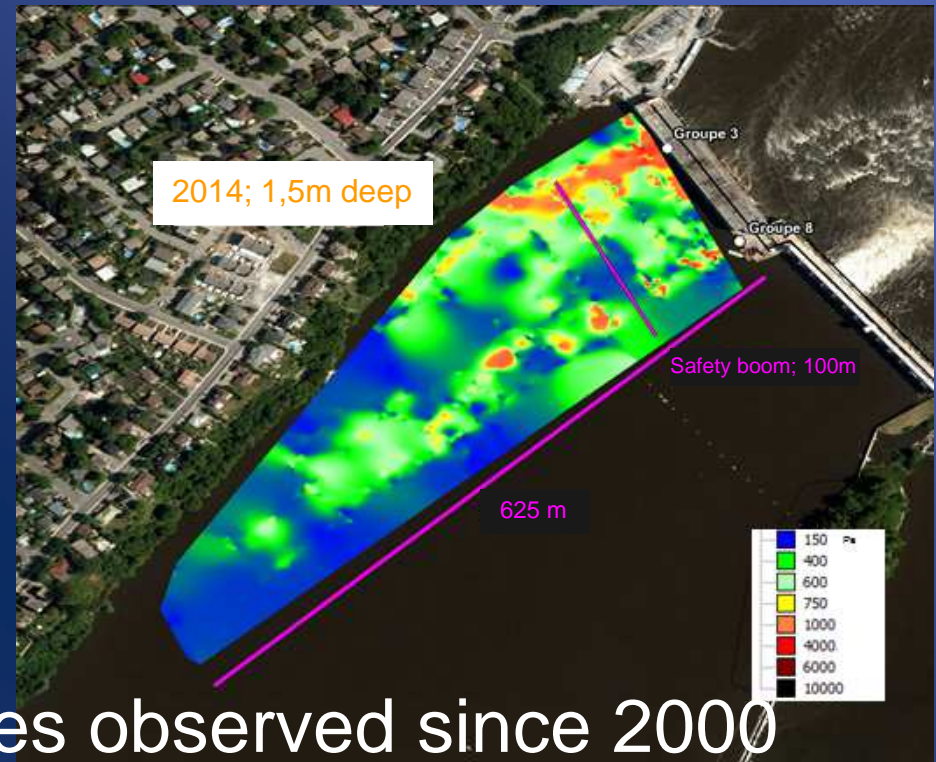
Albury Australia - Fish Passage 2018

Guidance system at the GS

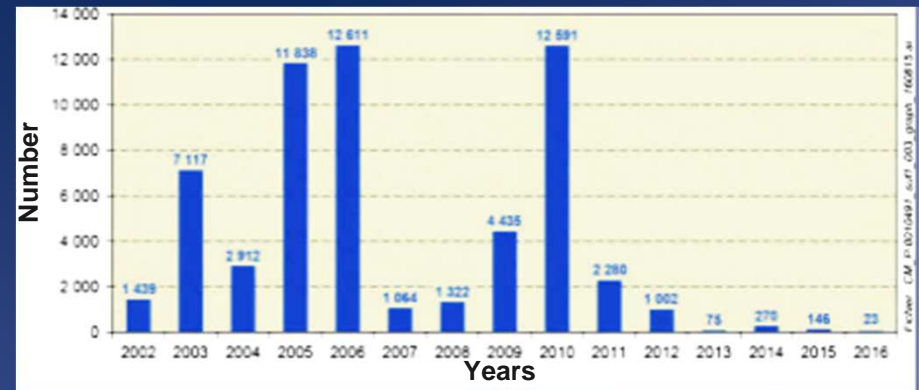
- ◆ Two ultrasound stations
 - Effective and reliable systems
 - Powerful: ± 238 dB, ref. $1 \mu\text{Pa}$ @ 1 m
 - 168 dB threshold at 600 m and more
 - Ok with GS operations
 - Two configurations:



Guidance system at the GS



- ◆ 2016: The lowest mortalities observed since 2000
 - 23 dead shads collected
 - Only one was injured

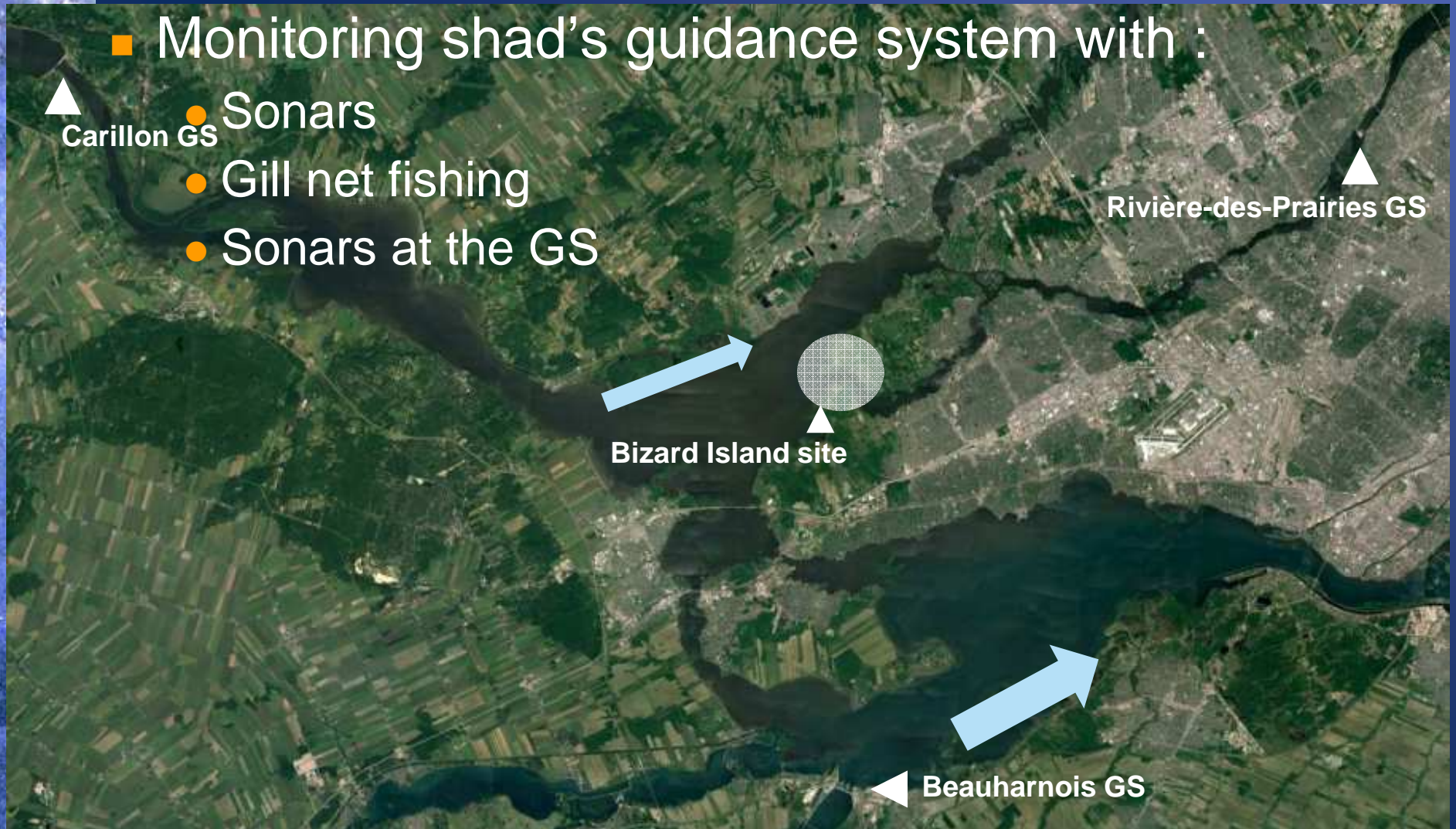


Prevent shad in the River: Bizard Island

◆ Autonomous sound generators

■ Monitoring shad's guidance system with :

- ▲ Carillon GS
- Sonars
- Gill net fishing
- Sonars at the GS



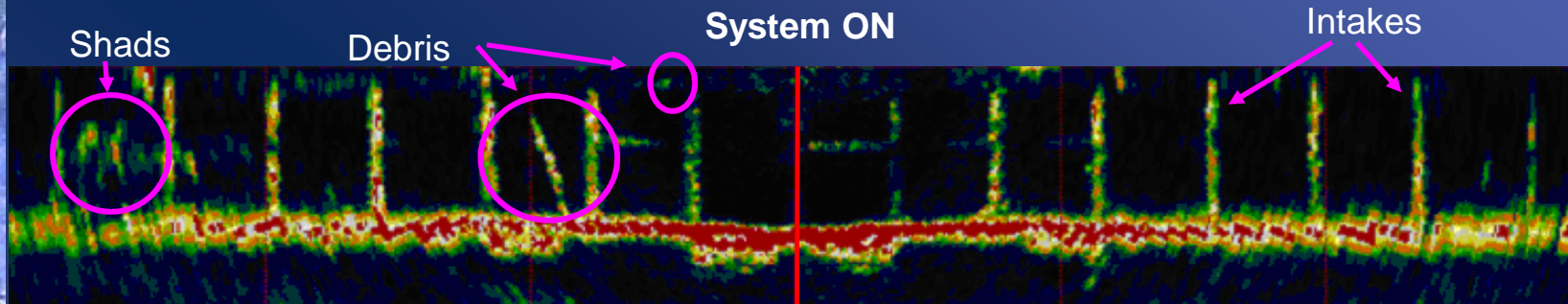
Prevent shad in the River: Bizard Island

- ◆ Solar panel ± 50 W (± 300 W at GS)
 - At GS, 109 emission parameters tested
- ◆ Buoys stable in lake and in river
 - Onboard communication card, pitch and roll sensor, GPS
 - Operation parameters remotely controlled
- ◆ Biology: no real guidance yet!
 - Geographic positioning tests (in or out river)
 - Gill net fishing: Mooneyes (*Hiodontidae tergisus*)
 - Down migration timing better known (3h-11h)

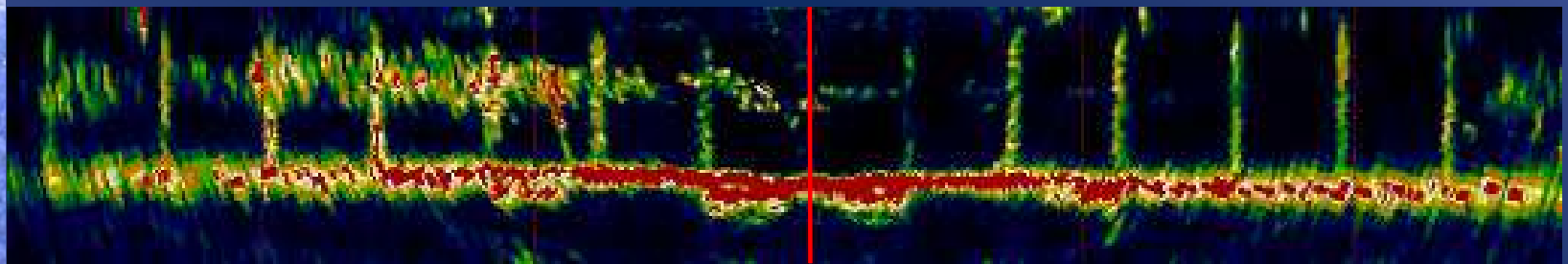
Questions ?



Guidance system 2006 - 2010



System OFF at 10:42



System ON at 11:12

