

Effects of Seismic Air- Guns on Fish

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What is known about effects of air-guns on fish?

- ❁ Several groups have looked at effects of air-guns on fish catch rate (e.g., work by Pearson et al.; Engås et al.)
- ❁ One study has investigated movements of fish on a reef (Wardle et al.)
- ❁ Effects on sensory cells of the ear (McCauley et al.)
- ❁ Effects on hearing (Popper et al.)
- ❁ Other direct or indirect studies on several species

Issues with studies

- ❁ Only done on a few of 25,000+ extant species
- ❁ Seismic exposure was limited
- ❁ Hard to determine effects on behaviors since fish either:
 - ❁ In cage where behavior is abnormal
 - ❁ In open ocean where cannot see immediate responses to exposure
- ❁ With few exceptions no one has looked at long-term effects or at gross pathology or histopathology

 **Extrapolation between species very problematic since:**

 **Behavior of species to a “freight” stimulus may vary widely**

 **Hearing capabilities varies widely**

 **Anatomy and physiology is very variable**

Focus of talk:

- ❁ Briefly discuss two types of studies
- ❁ Spend more time on one study that my group did in Canada last year

Effects on fish catch

Engås, A., Løkkeborg, S., Ona, E., and Soldal, A. V. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Can. J. Fish. Aquat. Sci.* 53, 2238-2249.

Pearson, W. H., Skalski, J. R., and Malme, C. I. (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp). *Can. J. Fish. Aquat. Sci.* 49, 1343-1356.

- 🐟 Studies exposed fish to air-guns
- 🐟 Examined catch rate before & after
- 🐟 Pearson et al. (several papers) with rockfish (*Sebastes* spp) saw small decline in catch rate and in behavior, but not extensive

- Engås et al. (several papers) found lowered trawl catch but returned in five days
 - Some effect on several north sea species
 - Not clear if fish died or left area
 - Not clear if returned catch were same or different fish
 - Did not observe fish behavior other than by sonar (in recent study by Slotte)


Effects on inner ear structure

McCauley, R.D., Fewtrell, J., and Popper, A.N. (2003). High intensity anthropogenic sound damages fish ears. *J. Acoust. Soc. Am.* 113:638-642.

- ❑ Exposed pink snapper (in cage) to air-gun
- ❑ Examined structure of the ear


Effects of Seismic Air-Guns on Three Species of Fish

Popper, A. N., Smith, M. E., Cott, P. A., Hanna, B. W., MacGillivray, A. O., Austin, M. E., Mann, D. A. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. J. Acoust. Soc. Am., 117:3958-3971.

 First study to measure effects on hearing in fishes exposed to seismic air-guns

 Looked at immediate post-exposure effects

 Also effects 24-hours post exposure

 Effects on swim bladder and gross morphology

 Done in Mackenzie River delta

 Reason was concern of the effects of oil and gas seismic exploration on local fishes



Mackenzie River





Air Gun Exposure

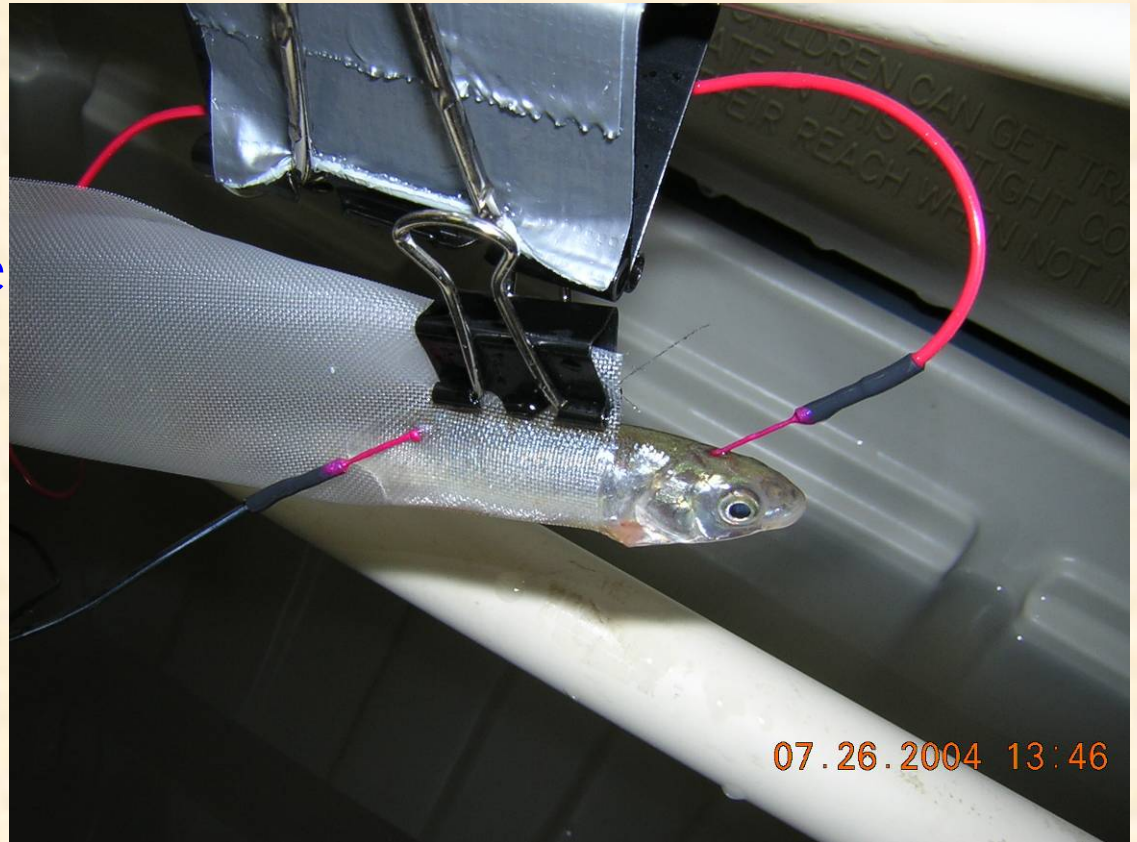


Overview

- ❏ Collect fish on Mackenzie
- ❏ Acclimate and then expose to air guns
- ❏ Remove fish and do test hearing within 45 minutes of exposure (use ABR)
- ❏ Dissect ears, inspect viscera
- ❏ Some fish not tested for 24 hours to test recovery
- ❏ Five or 20 air gun shots – over 205 dB peak, over 175 dB SEL

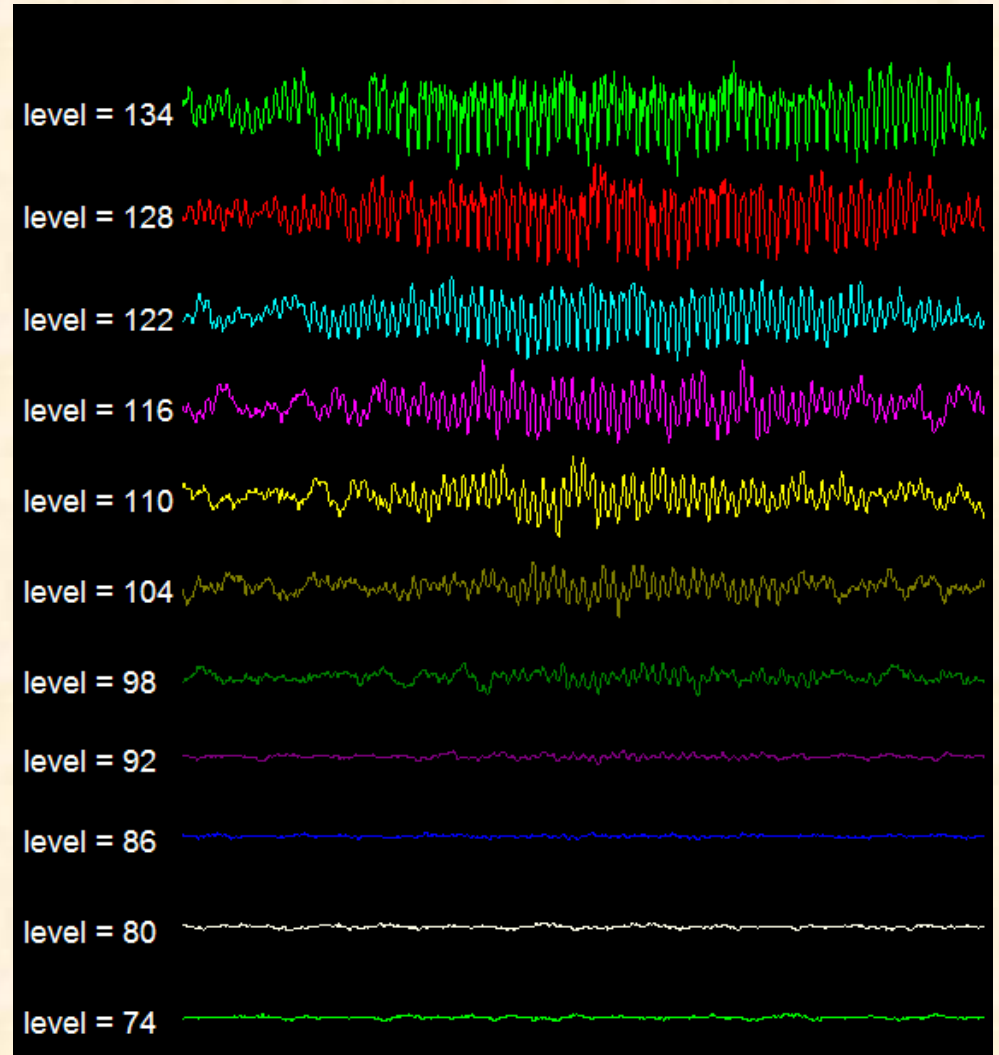
Auditory Evoked Potentials

- ❁ Lake chub
(specialist)
- ❁ Northern pike
(non-specialist)
- ❁ Broad whitefish
(non-specialist, salmonid)



EPs in Response to 800 Hz

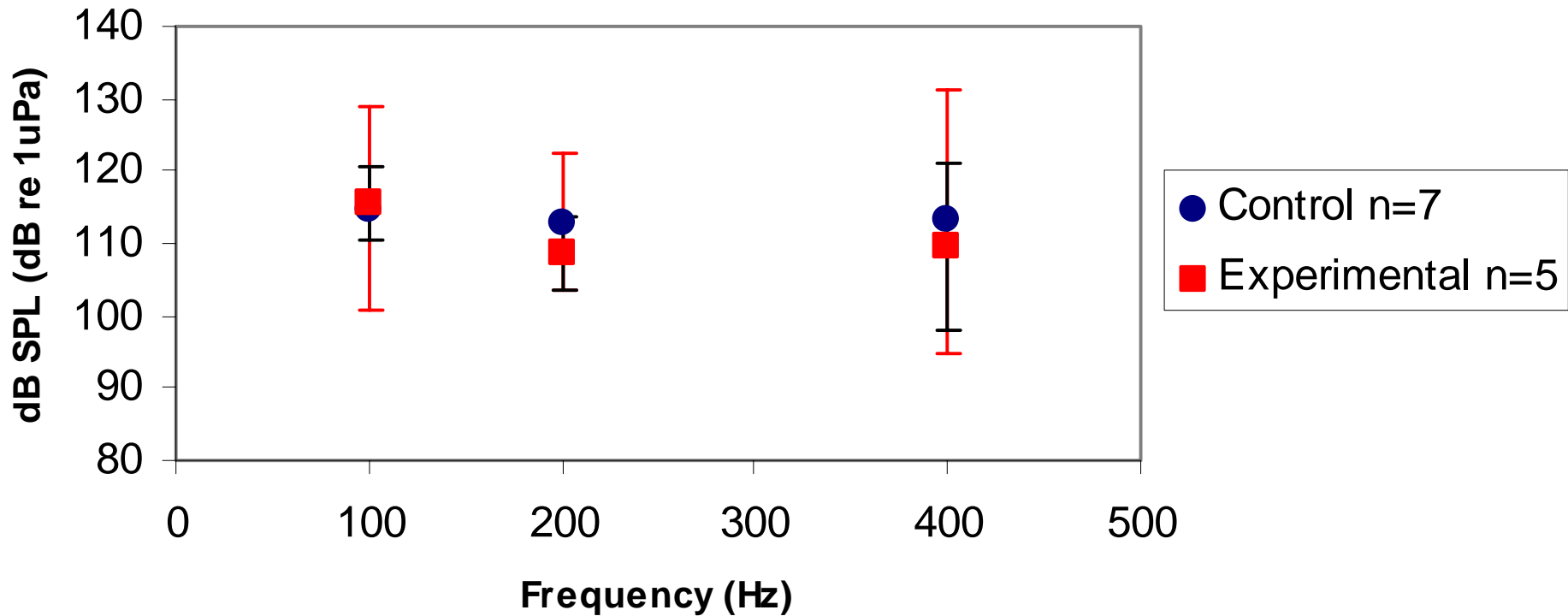
- 50 ms duration
- Threshold Determination



Broad Whitefish (Salmonid)

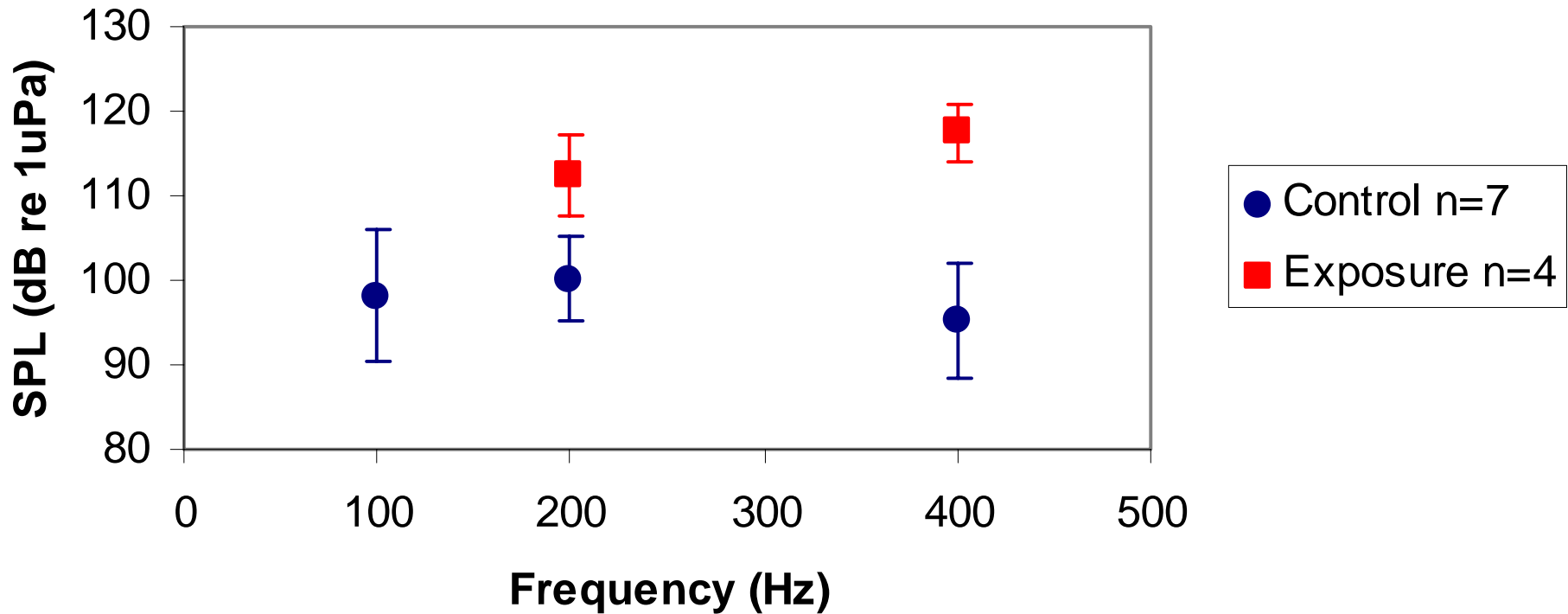
- Five Shots

Broad Whitefish



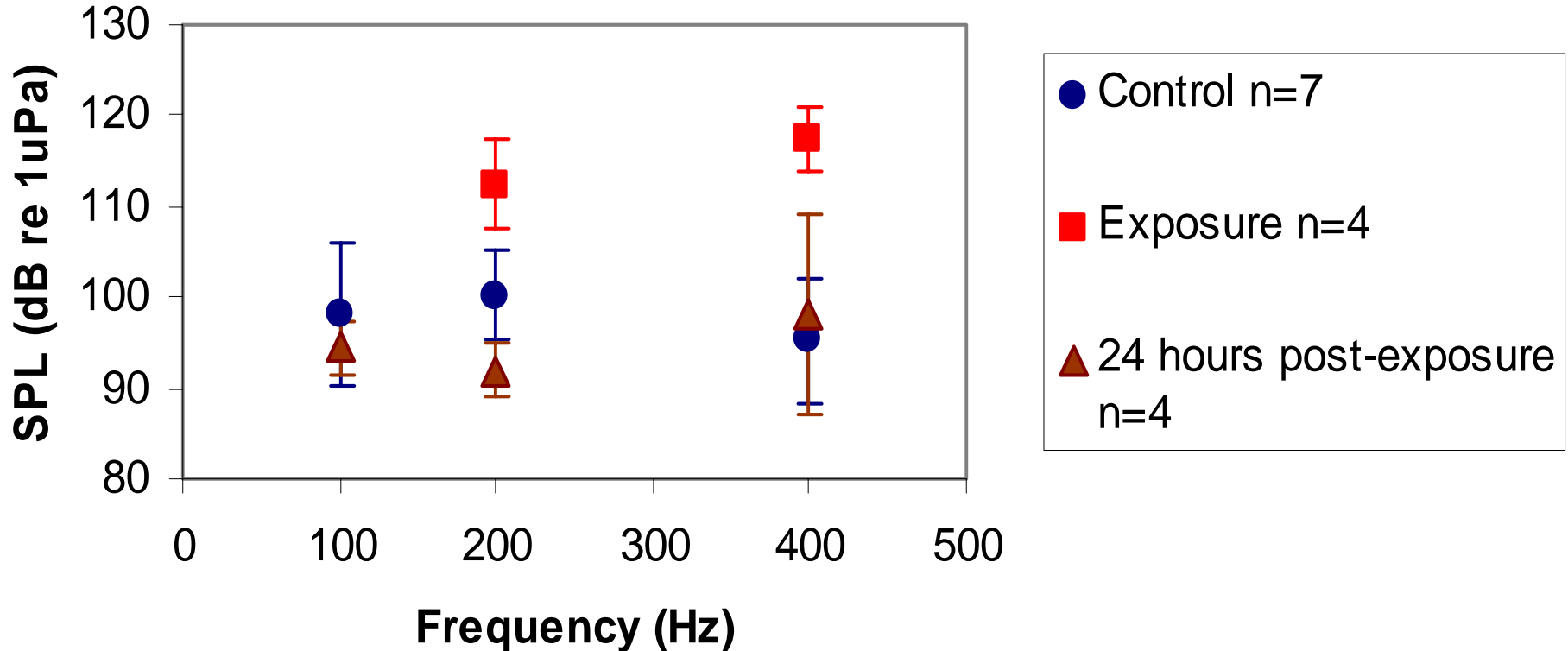
Northern Pike - Five Shots

Northern Pike Adult

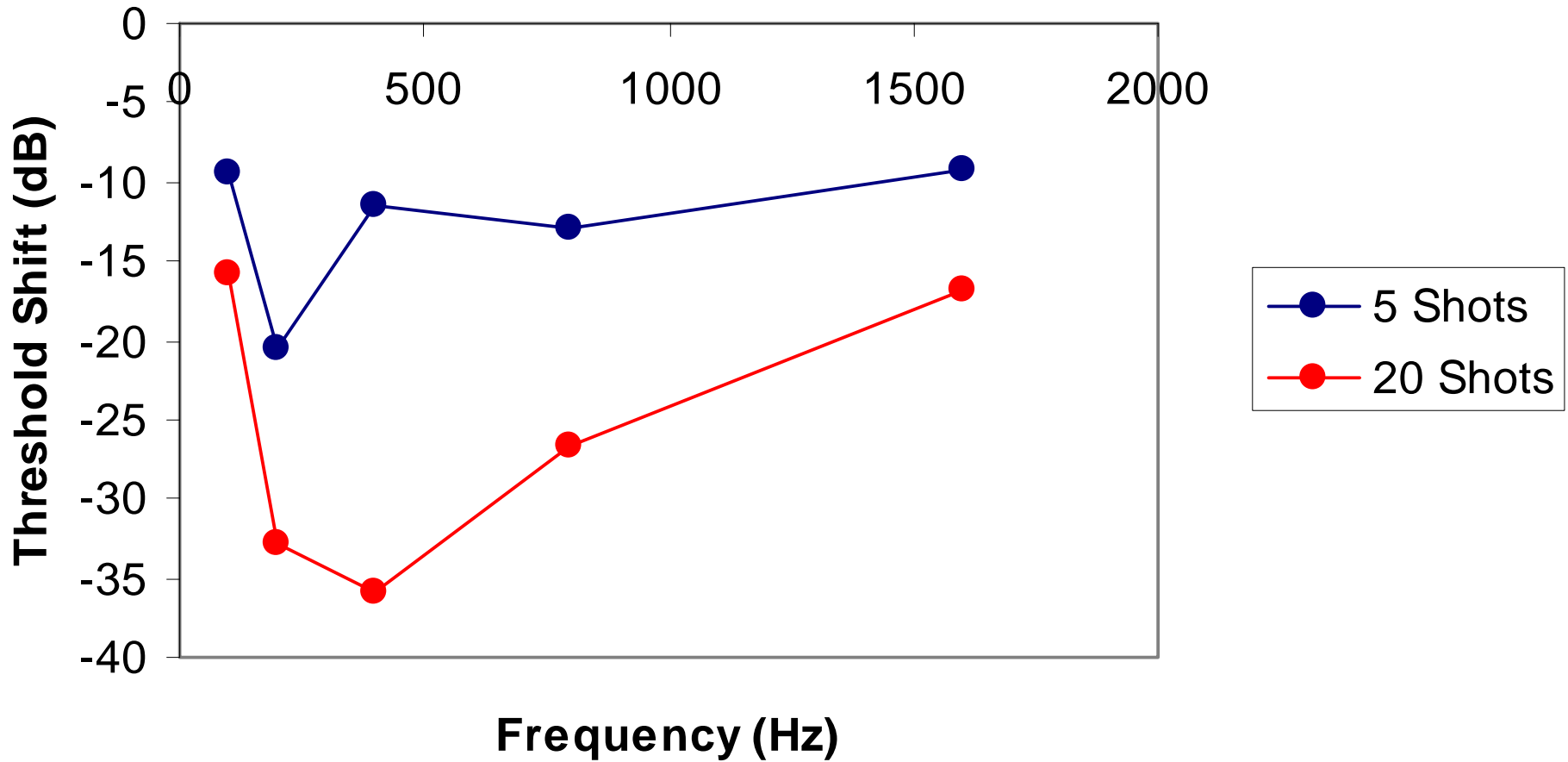


Northern Pike five Shots: 24 hours post-exposure

Northern Pike Adult

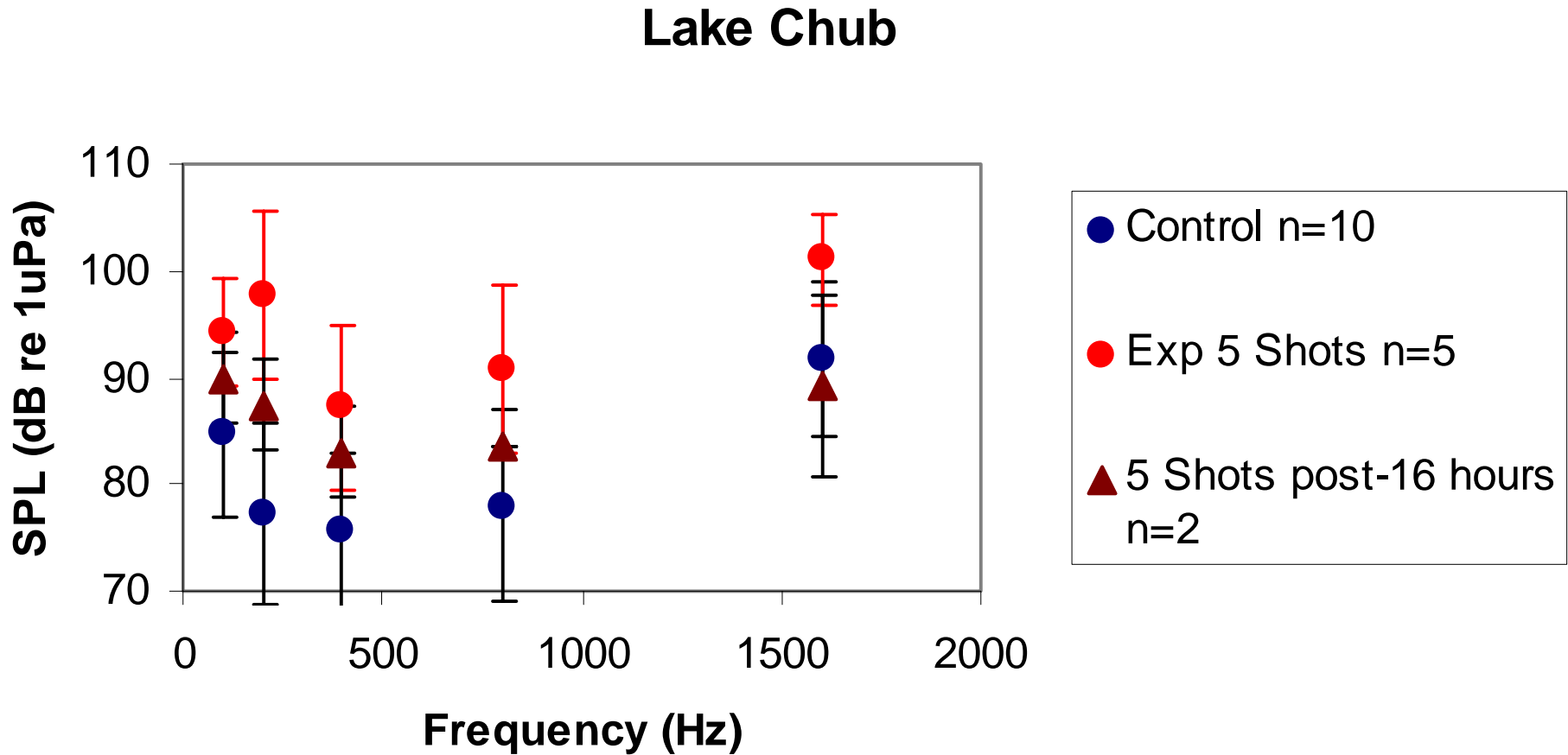


Lake Chub Immediate Threshold Shift



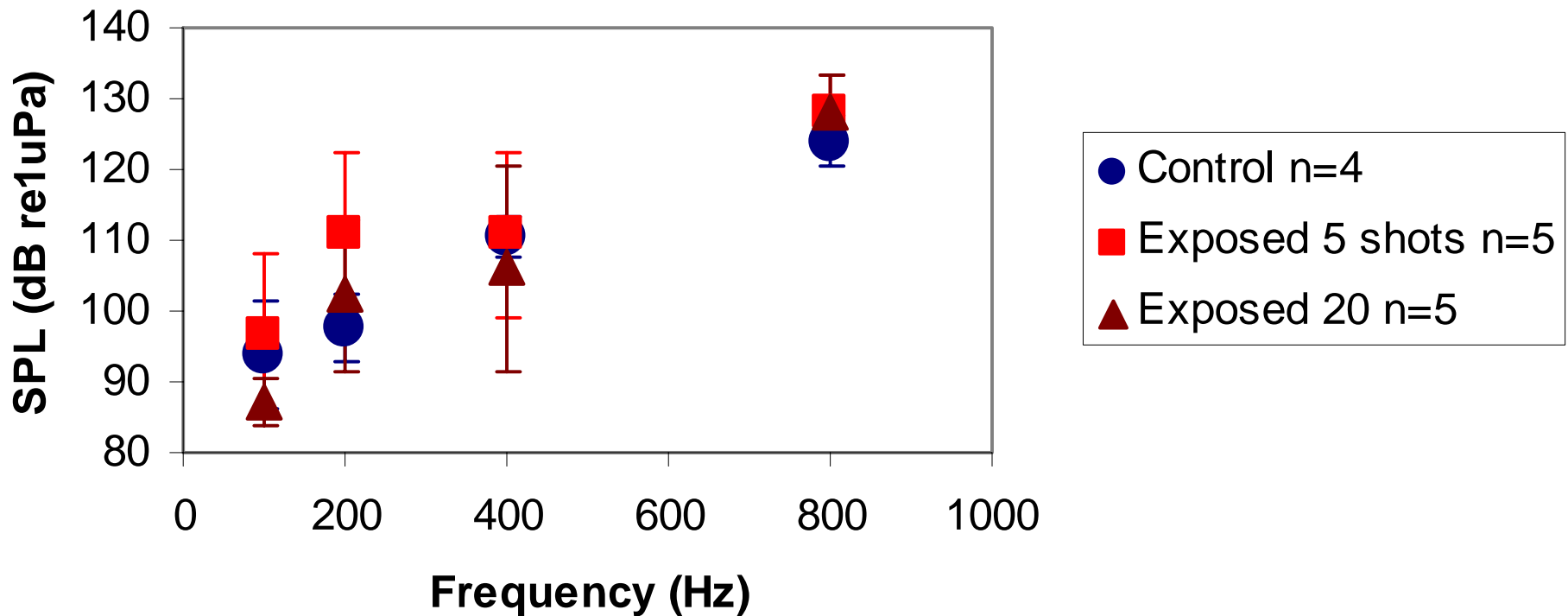
Lake Chub Five Shots: 24 Hours

Post-Exposure



Northern Pike Juveniles





Juvenile Northern Pike



Morphological Observations

- ❑ No apparent damage to swim bladder or other tissues examined immediately after exposure
- ❑ No damage to the inner ears (SEM studies)
- ❑ Fish survived for duration of study

Mackenzie Conclusions

-  **Hearing Losses Were Greatest for Fish with Most Sensitive Hearing**
 -  **Lake Chub, an otophysan, showed greatest hearing loss, with increasing hearing loss with exposure level**
 -  **Northern Pike showed a small hearing loss**
 -  **Broad Whitefish showed no hearing loss**

Mackenzie Conclusions

- Threshold shifts increased with increasing exposure
- All hearing losses were temporary, and recovered within 24 hours
- Juvenile N. Pike showed no hearing loss, yet adults did.



Effects of air-guns on fish - 1

- ❁ Limited data to suggest a few species will move from a sound source. This may result in temporary decline in catch. BUT:
 - ❁ Needs replication on more species
 - ❁ Needs replication in different parts of the ocean
 - ❁ May have different effects on fish of different sizes/ages
 - ❁ Have to observe fish behavior
- ❁ No clear conclusions can be reached on catch at this time!

Effects of air-guns on fish - 2

- ❏ May be some damage to sensory tissues. BUT:
 - ❏ Fish survived in the experiments
 - ❏ Do not know effects, if any, on other organ systems
 - ❏ Only one species
 - ❏ Needs replication with other species
 - ❏ Need to examine other tissues
 - ❏ Need better understanding of acoustics
- ❏ Results of limited value at this time and should not be used without replication of work.

Effects of air-guns on fish - 3

- Temporary hearing loss in some, but not all, species. Always get 100% recovery. BUT
 - Needs replication on other species
 - Needs different sound environments
 - Results may only be applicable in river where lower frequencies of the seismic device does not travel far
- Tentative conclusion that under conditions used in our tests, there is no permanent impact on fish. BUT, only in a river!!

Collaborators

- ❁ Peter Cott & Bruce Hanna, *Department of Fisheries and Oceans, Western Arctic Region, Canada*
- ❁ Alex MacGillivray & Melanie Austin, *JASCO Inc, Vancouver, Canada*
- ❁ David A. Mann, *University of South Florida*
- ❁ Jiakun Song, *University of Maryland*