



The Pathway

A program for regulatory certainty for instream tidal energy projects

Presentation

Scientific Echosounder Review for In-Stream Tidal Turbines

Principle Investigators

Dr. John Horne

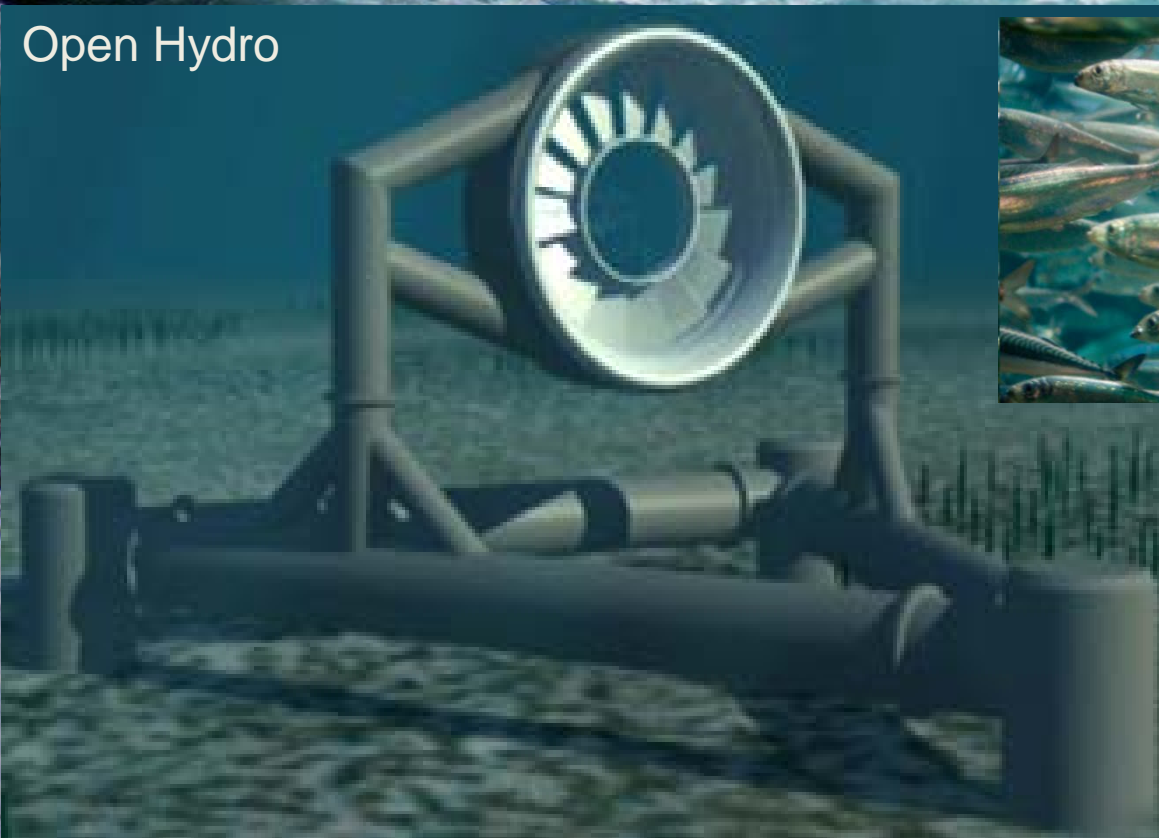
August 2019

Scientific-grade echosounders are a standard tool in fisheries science and have been used for monitoring the interactions of fish with tidal energy turbines in various high flow environments around the world. Some of the physical features of the Minas Passage present unique challenges in using echosounders for monitoring in this environment (e.g., entrained air and suspended sediment in the water column), but have helped to identify hydroacoustic technologies that are better suited than others for achieving monitoring goals. John Horne's report and presentation will present an overview of echosounders and associated software that are currently available for monitoring fish in high-flow environments, and identify those that are prime candidates for monitoring tidal energy turbines in the Minas Passage.

This project is part of "The Pathway Program" – a joint initiative between the Offshore Energy Research Association of Nova Scotia (OERA) and the Fundy Ocean Research Center for Energy (FORCE) to establish a suite of environmental monitoring technologies that provide regulatory certainty for tidal energy development in Nova Scotia.

Listening in the Noise

Open Hydro



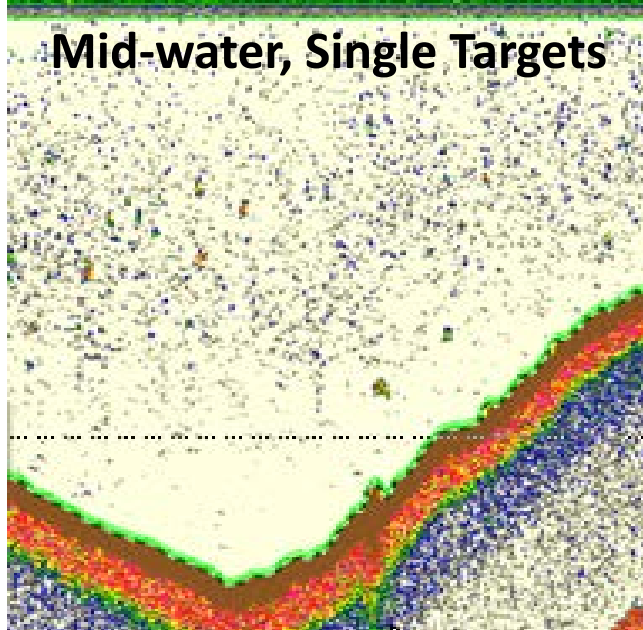
oera
webinar
series

John K. Horne
University of Washington



Typical Acoustic Targets

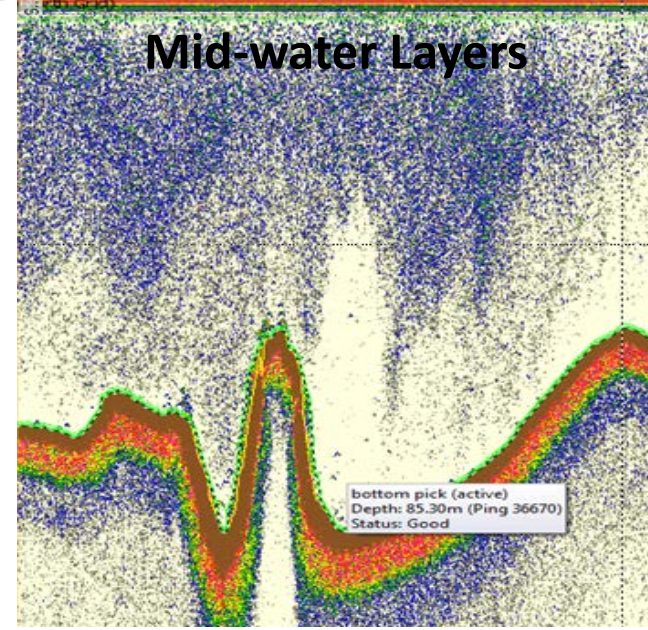
Mid-water, Single Targets



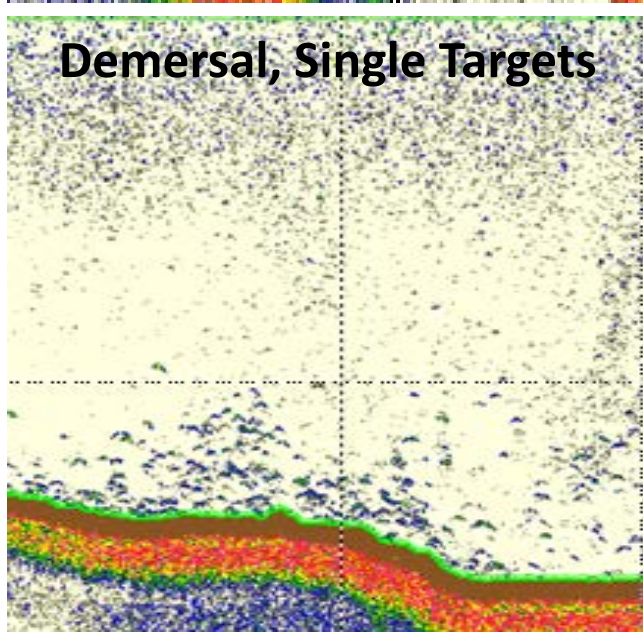
Echo
Counting

Echo
Integration

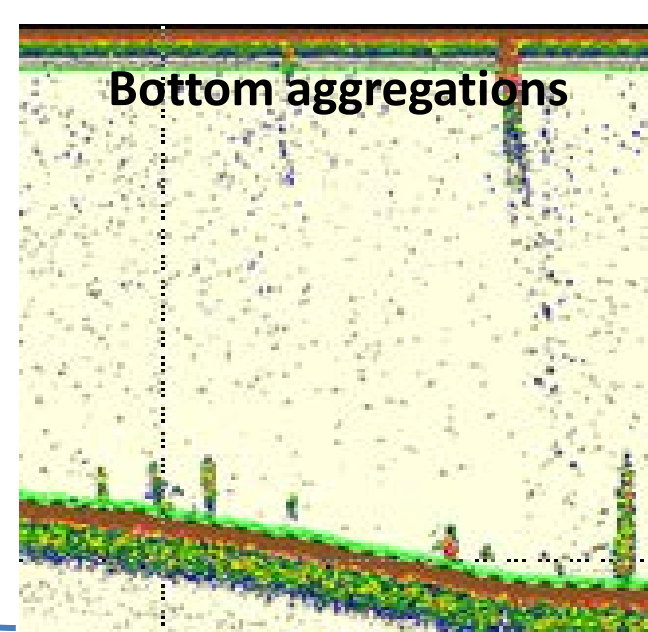
Mid-water Layers



Demersal, Single Targets

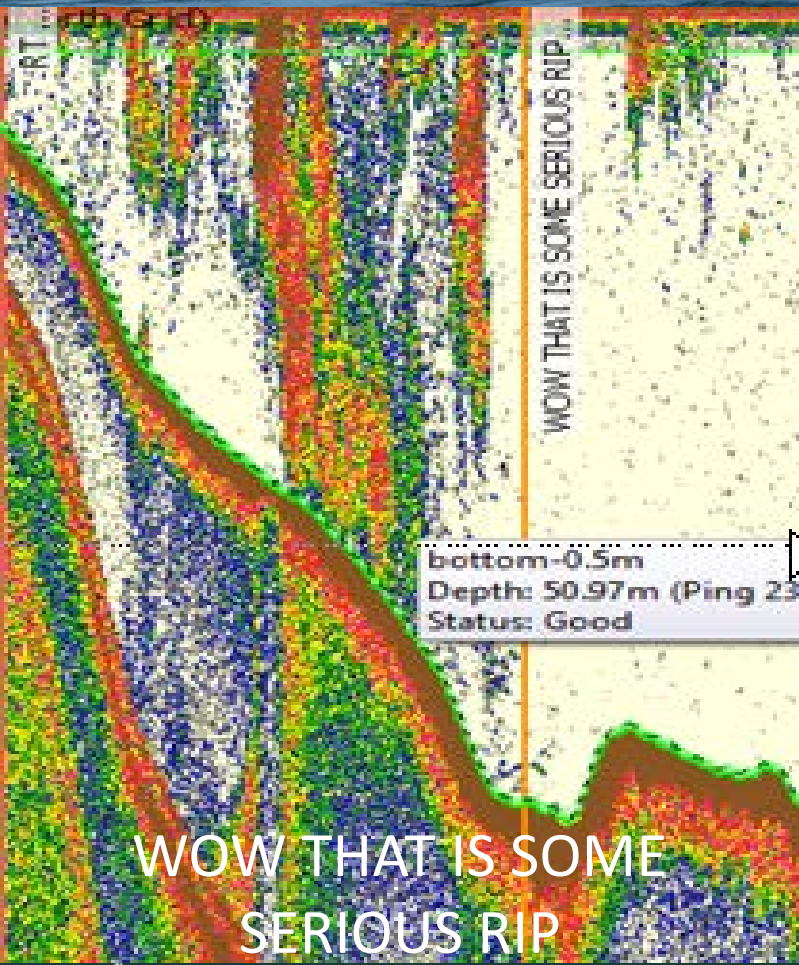


Bottom aggregations



Using Sound as a Sensor:

How to detect swimbladdered fish in bubbly, turbulent water?



What is an Echo?

An acoustic impedance mismatch resulting in a reflection

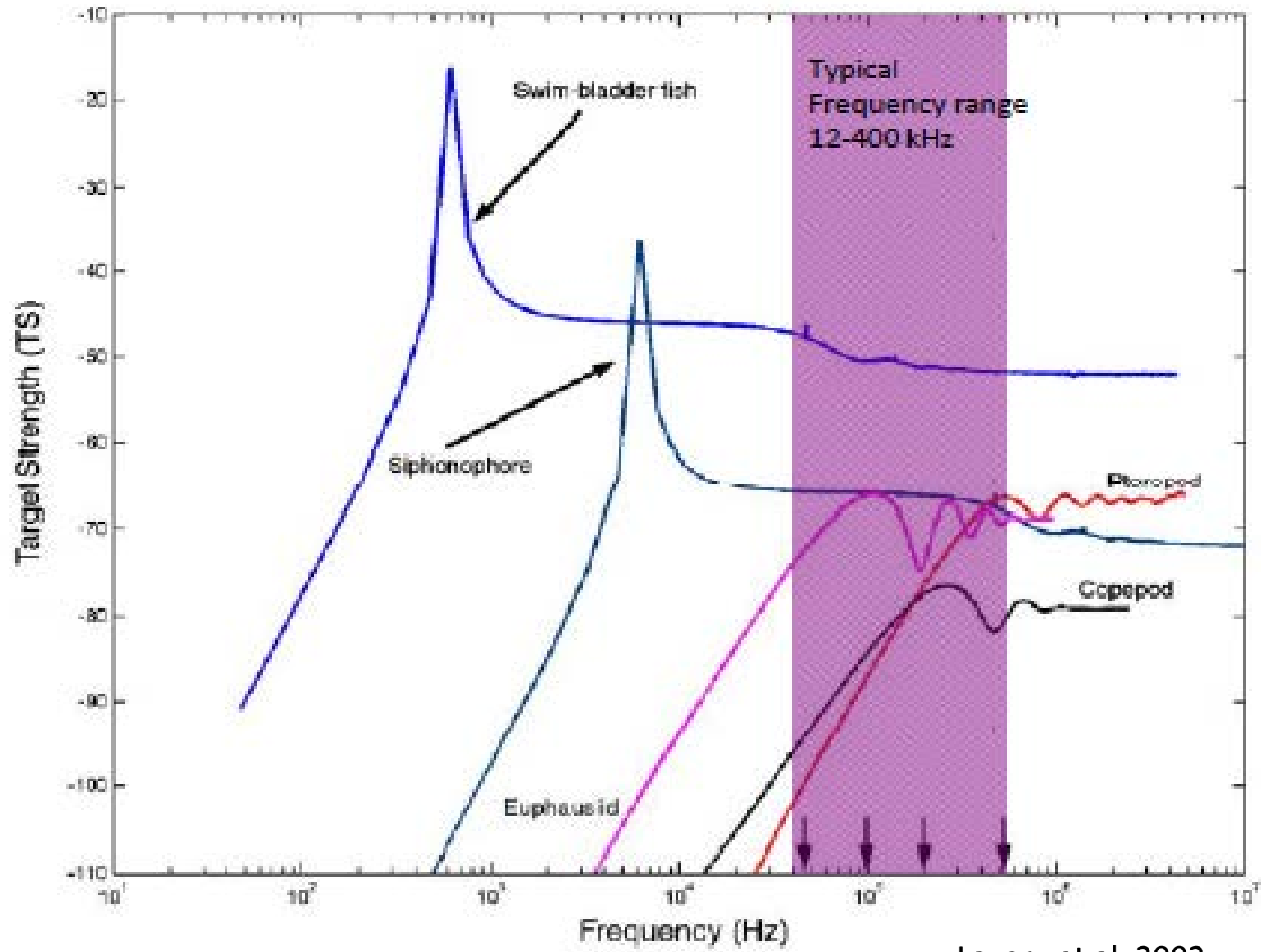
Acoustic Impedance (Z) $Z = \text{density} \times \text{sound speed} = \rho c$

Comparing Impedance
at an Interface

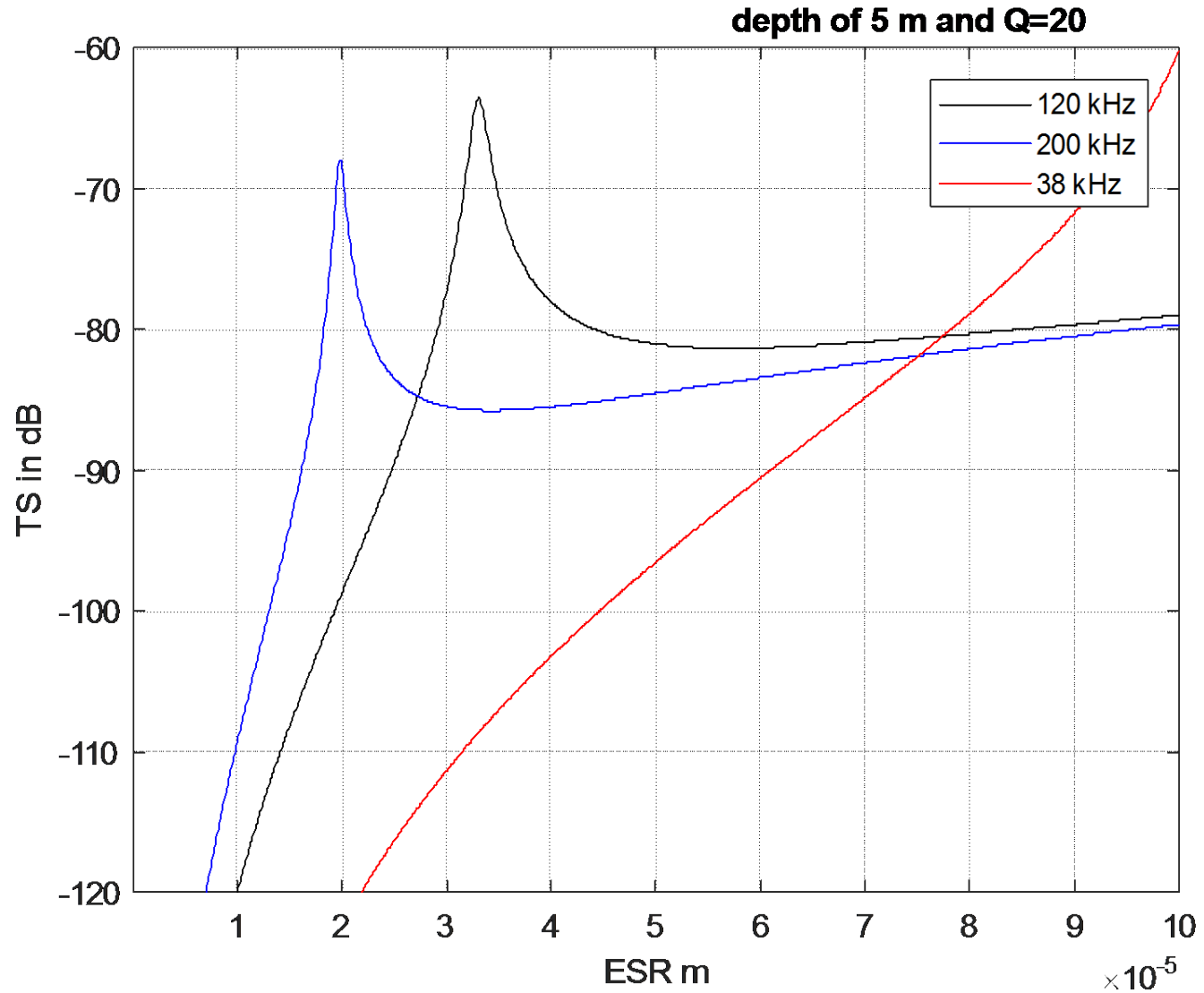
$g = \rho_2/\rho_1$	$h = c_2/c_1$
density contrast	sound speed contrast

Anything with a density different than
water will reflect sound

Echo Amplitudes f(Frequency)



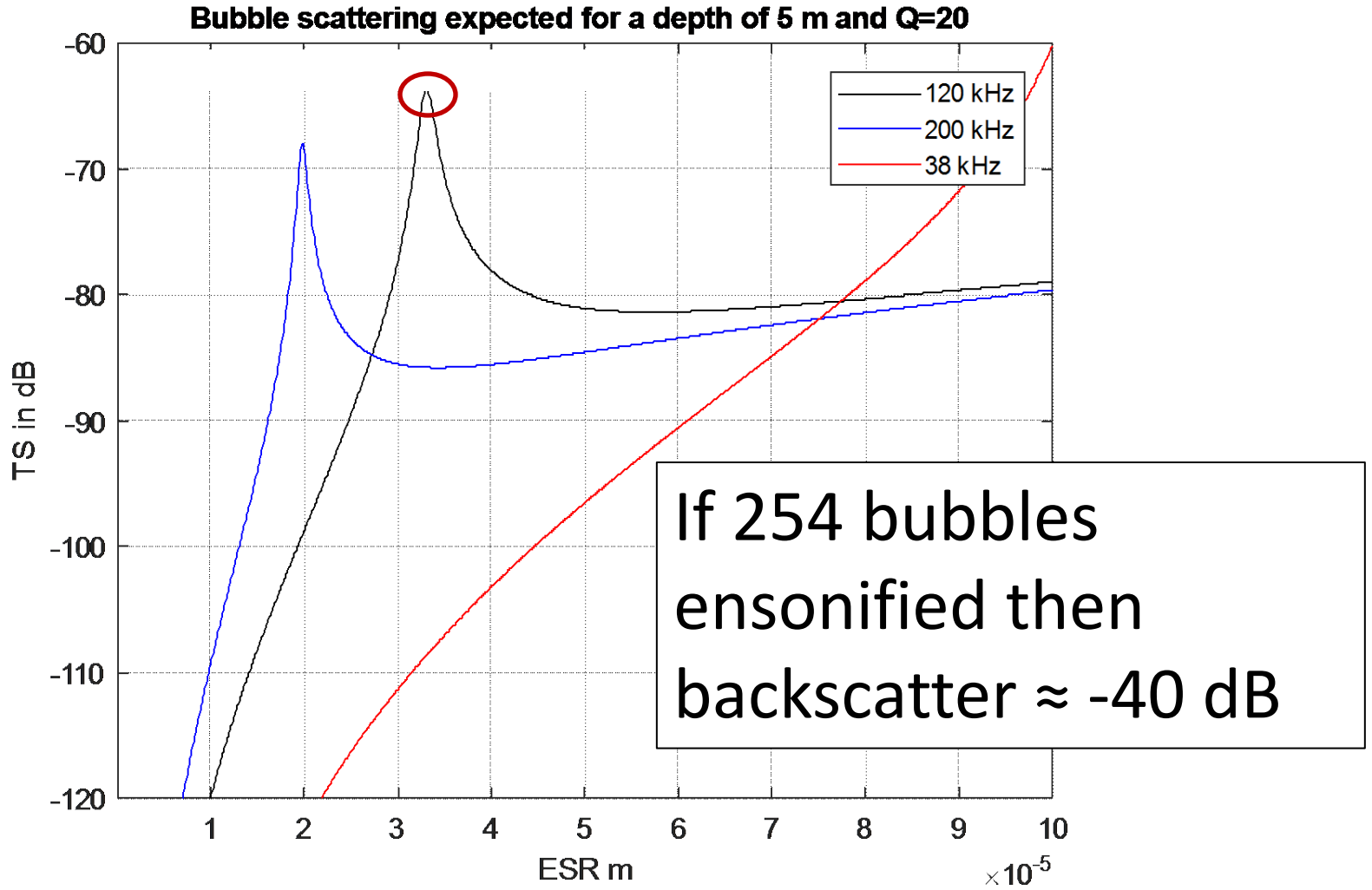
Bubble TS: Model Estimate



Courtesy of T. Ryan

Bubble Ensemble

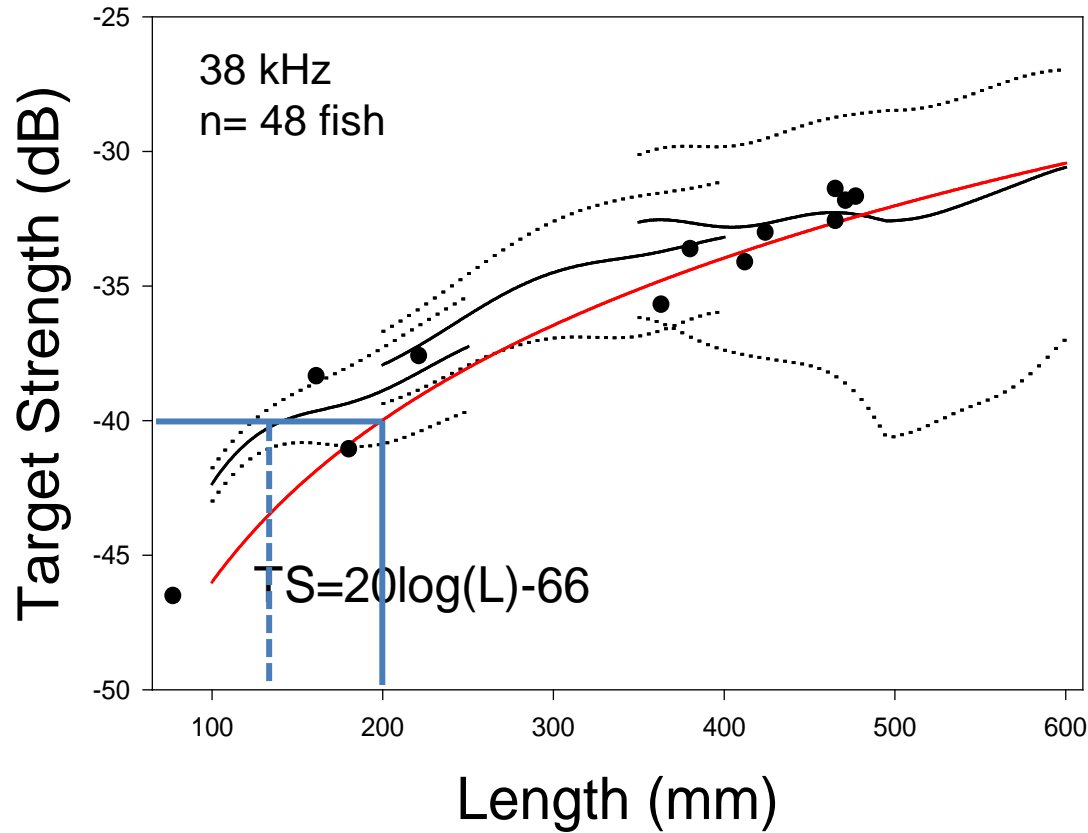
TS of 0.06 mm bubble (width of human hair) at 120 kHz \approx -64 dB



Fish Target Strengths

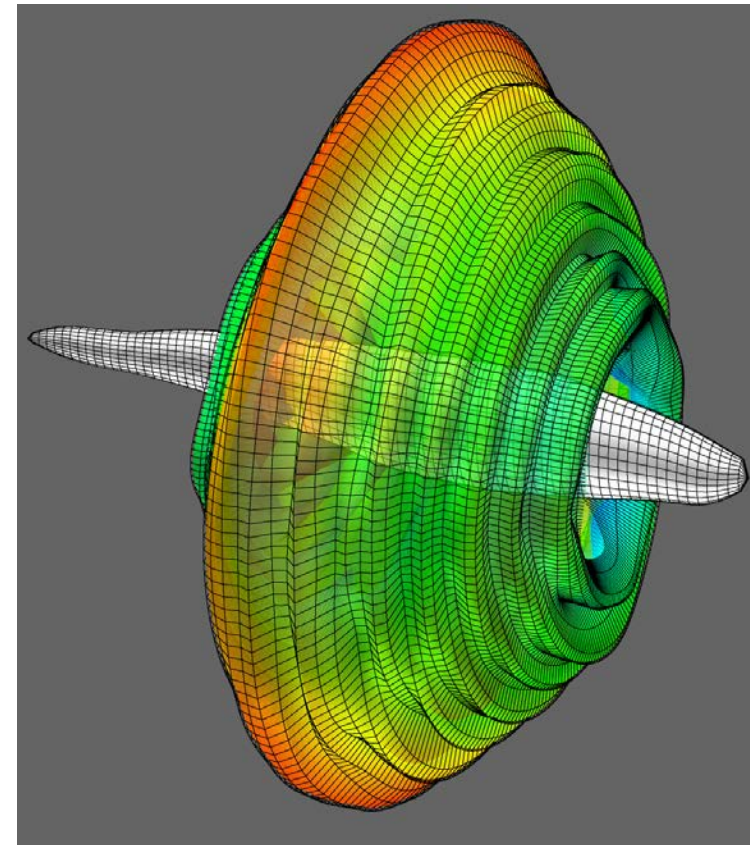
Walleye pollock (*Gadus chalcogrammus*)

comparison of backscatter to statistical model



Horne 2003

Backscatter Model Visualization



Needed Sensor Characteristics

General

Calibratable: accuracy and precision of measurements

Constant source level and TVG: accuracy and precision of measurements

Known beam pattern: accuracy and precision of measurements

Digital output: data processing and analysis

Data Processing

compatible with commercial processing software for bulk processing
(Echoview, LSSS, SonarX)

MRE

Maximize SNR: CHIRP signal + matched filter for target detection

Physical footprint and packaging: 'fit' in deployment platform

Power and communications: 'fit' with deployment strategy and sample design

What Determines Echo Amplitude?

Simplified Sonar Equation

Echo Amplitude = Source Level + Target Echo + Beam Compensation – Transmission Loss

$$EL = SL + TS + 2D_i(\phi, \theta) - (40\log(r) + 2\alpha r)$$

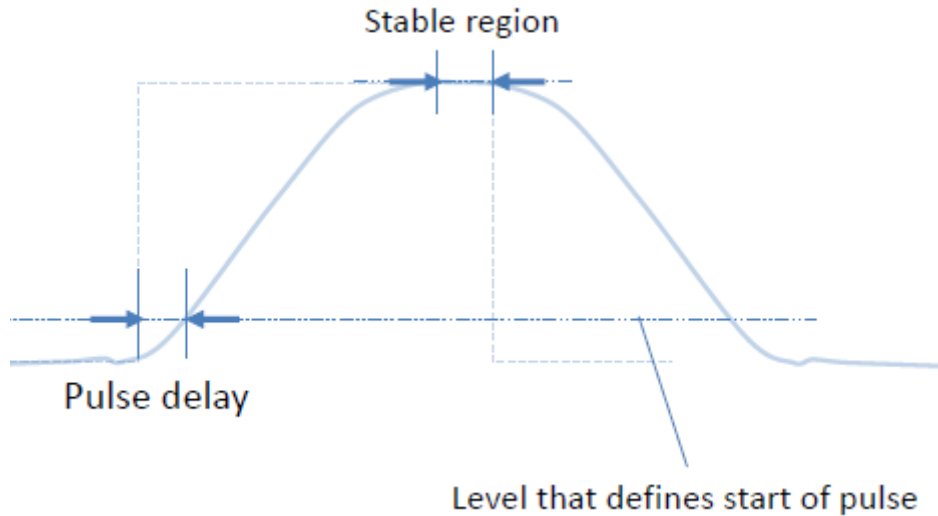
Echo Level Source Level Target Strength Beam Directivity Spreading Absorption

How to Increase Echo Amplitude (relative to noise)?

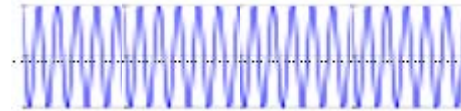
1. Increase source level (amplifies everything)
2. Reduce distance to targets (strategic deployments)
3. Increase signal-to-noise ratio (increase signal (see 1), reduce noise, change pulse type)
4. Match transmit frequency to target resonance peak (lower transmit frequency but operational and regulatory constraints)
5. Process data to remove noise (ambient noise filter, mask unwanted targets)

Transmit Pulse Types

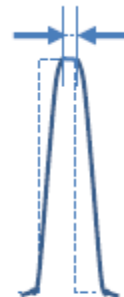
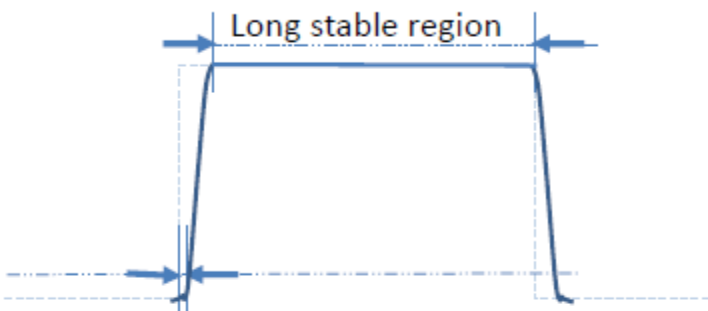
Narrowband



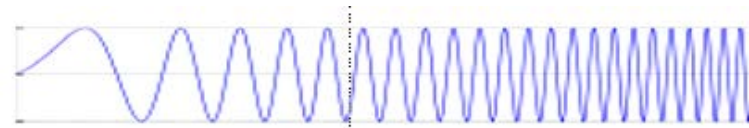
Continuous Wave (CW)



Broadband



Frequency Modulated (FM) Linear up-sweep (CHIRP)

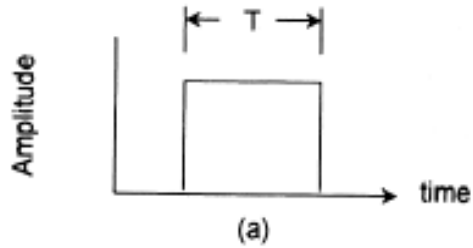


Very little
pulse delay

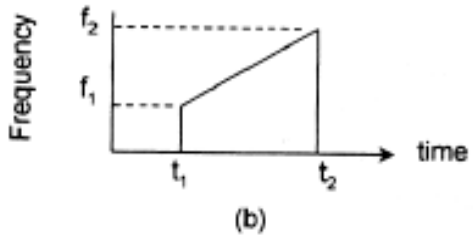
Broadband: very short pulses possible
=> High spatial resolution is possible

Broadband Matched Filtering

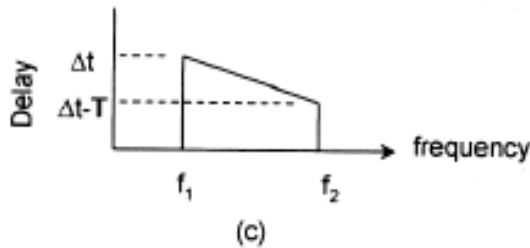
Transmit Pulse



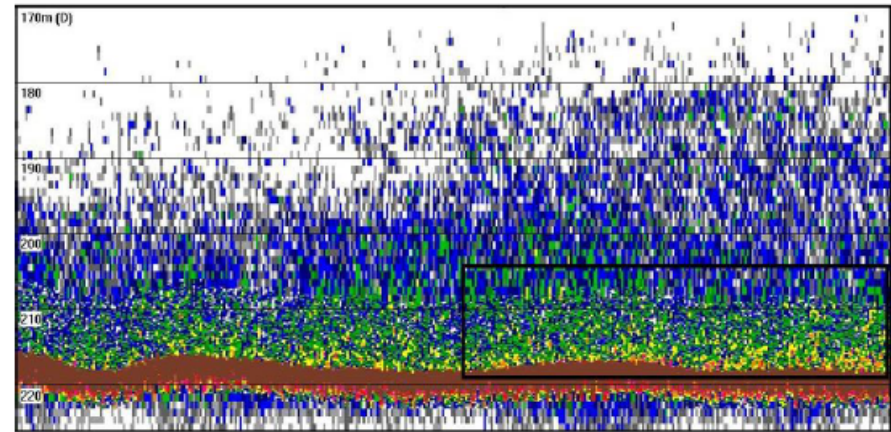
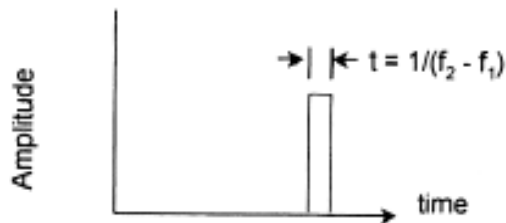
Time-dependent Frequency



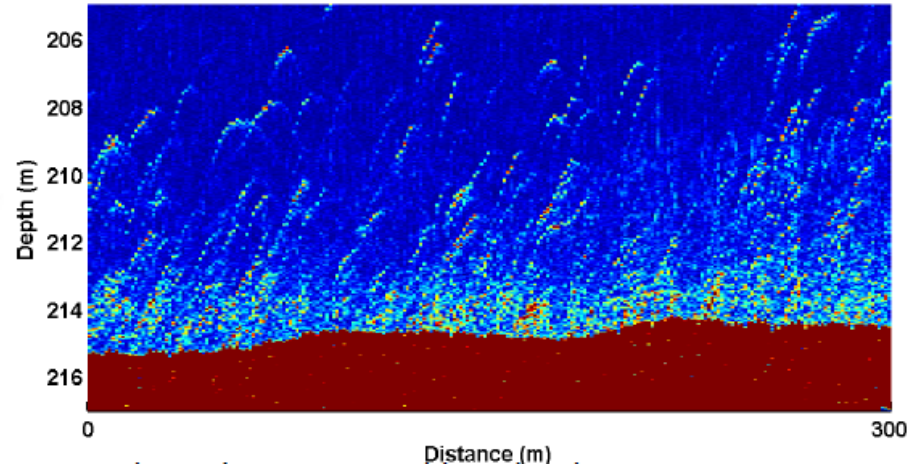
Receive Echo Delay



Receive Echo Amplitude



Atlantic Herring



Stanton 2010

Ehrenberg & Torkelson 2000

SNR increase ~ 15 dB over CW pulse
(depends on pulse bandwidth)

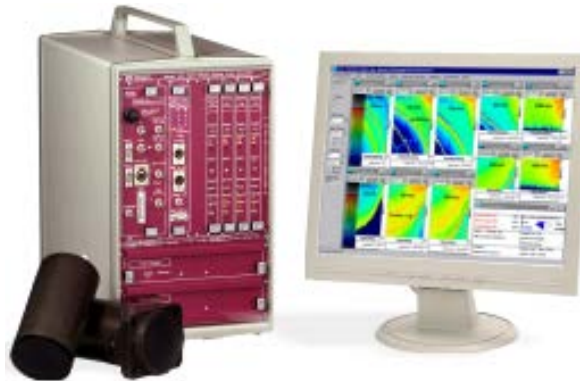
Commercial, Scientific Echosounders

Tier I: calibrated, internationally vetted, digital output

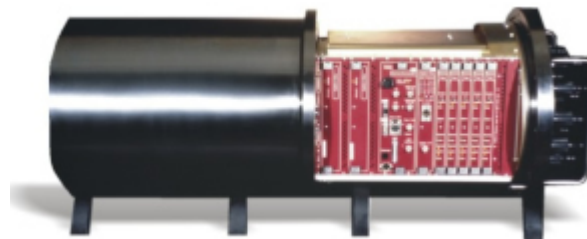
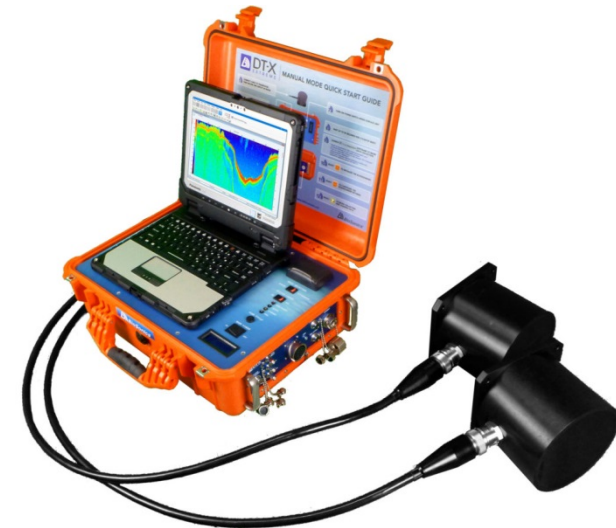
Simrad EK80



HTI Model 244



BioSonics
DTX Extreme



Commercial, Scientific Echosounders

Tier II: calibratable, consistent TVG, international vetting underway

ASL AZFP



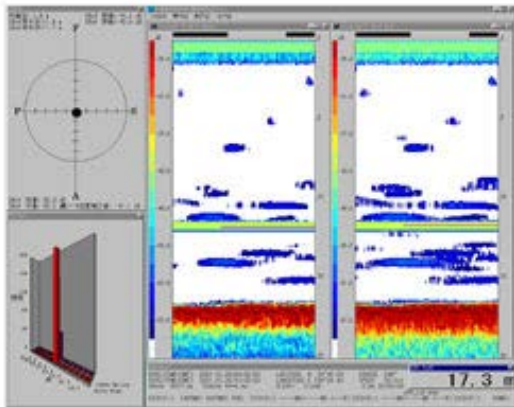
Nortek
Signature 100



Commercial, Scientific Echosounders

Tier III: not internationally vetted

Kaijo/Sonic
KFC-3000



Furuno FQ80



Imagenix 853

