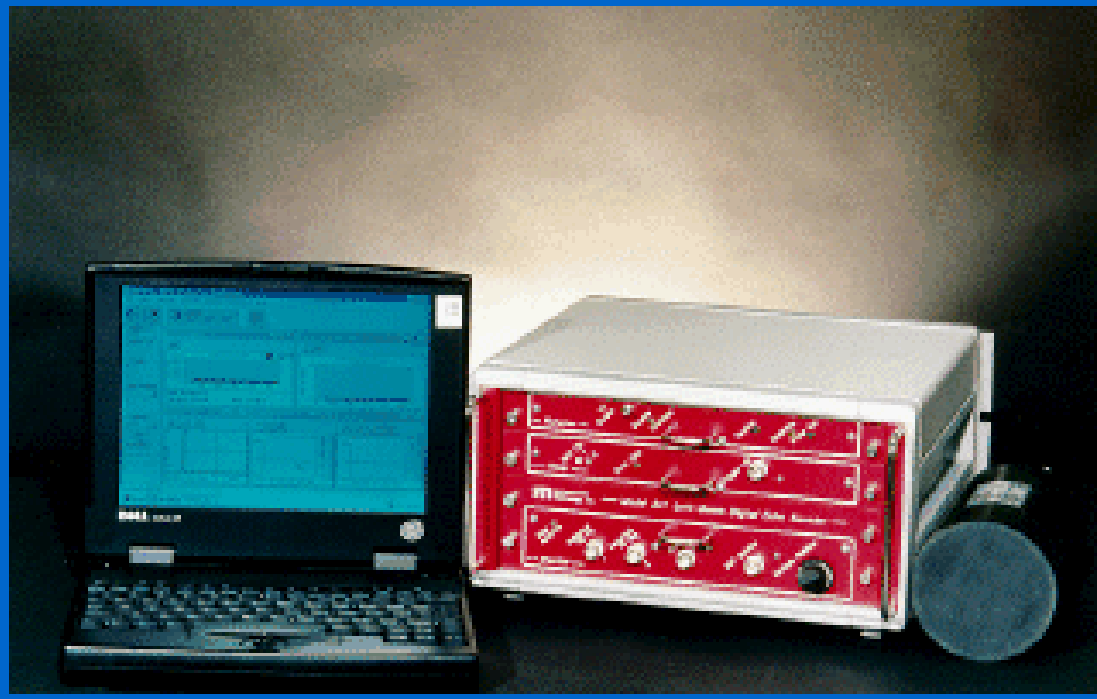
Chapter 13

Acoustic Assessment of Fish Abundance and Distribution

13.1 Introduction

- Introduction to underwater acoustics and measurement of fish
- Commonly used terms- refer to Box 13.1



Definition of Fisheries Acoustics

- Use of transmitted sound to detect fish
- Reflect sound as density of fish and water differ

Referred to in several ways

- Fisheries acoustics
- Hydro-acoustics
- Underwater acoustics
- Echo sounding

Sonar (acronym)

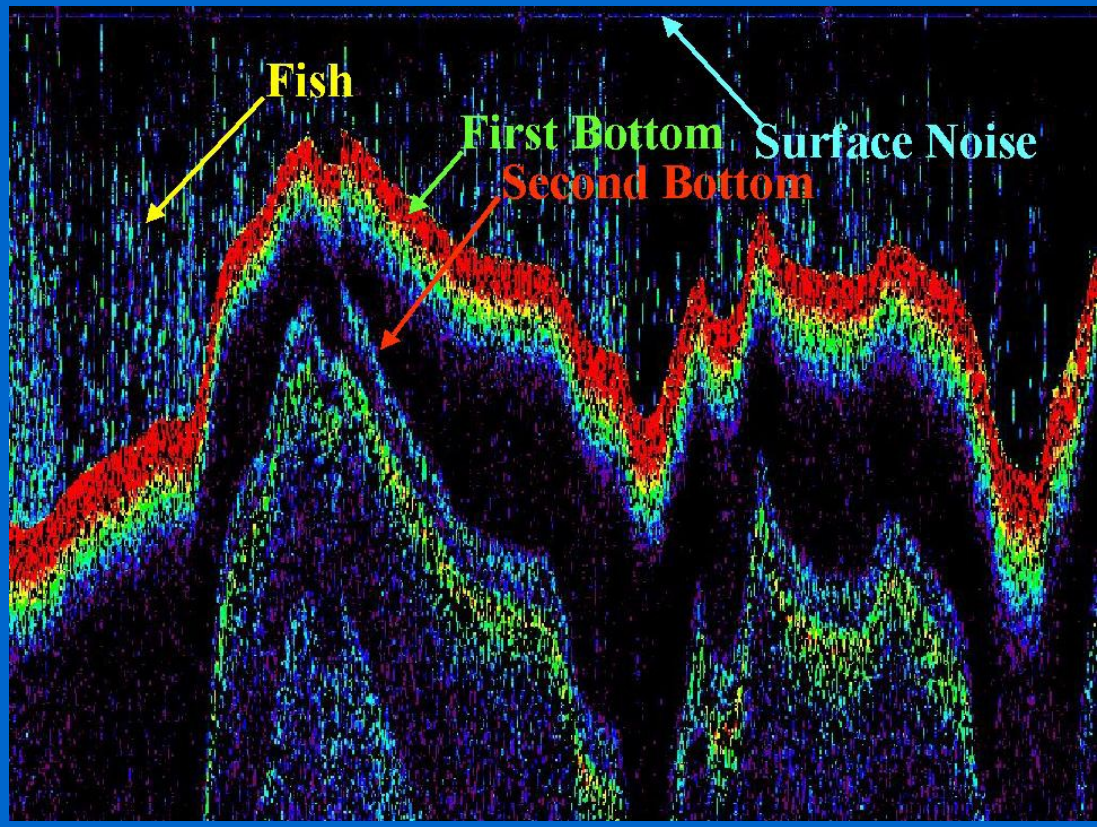
- ***S***ound ***N***avigation and ***R***anging applications

History and Current Status

- Developed largely during to 1st World War
- First used to record presence and absence of fish
  - Locate aggregations of fishes
  - Limited to open water
- Now used for stock assessment and ecological research

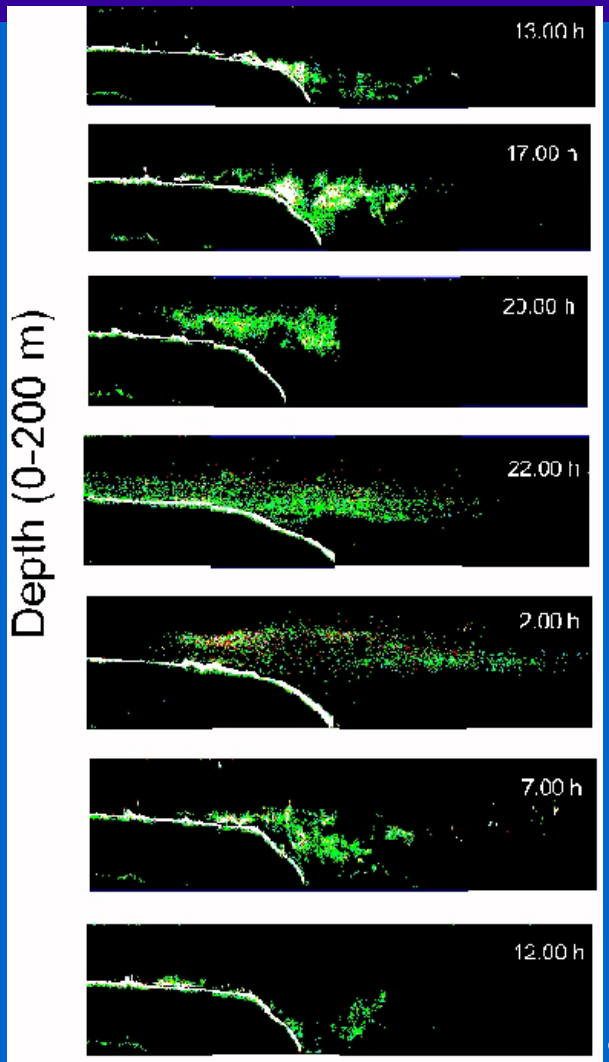
Applications

- Stock assessment (marine environments)
- Fish biomass
- Numerical abundances
- Mean sizes



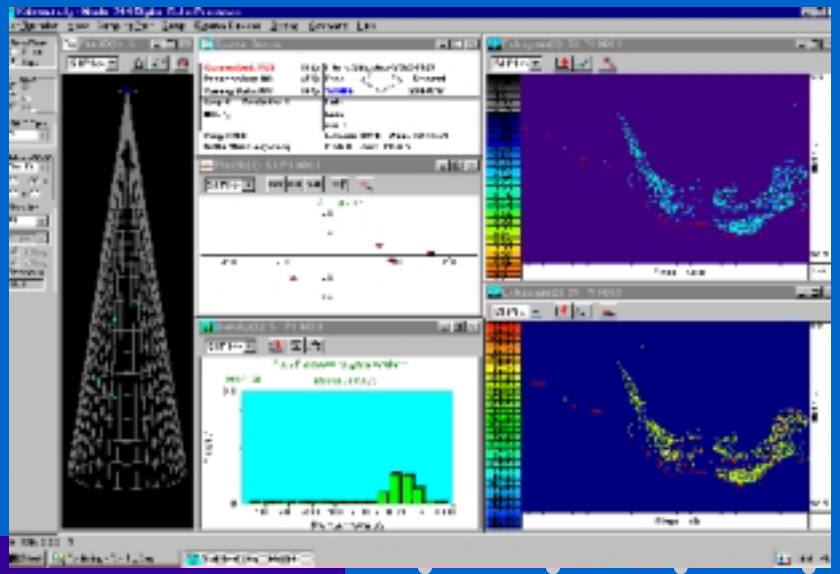
Applications (cont.)

- By commercial fisheries to find concentration of fish
- Distribution and biology of zooplankton



Advantages and Limitations: Advantages

- No disturbance caused to the creatures or environment
- Entire water column can be sampled quickly

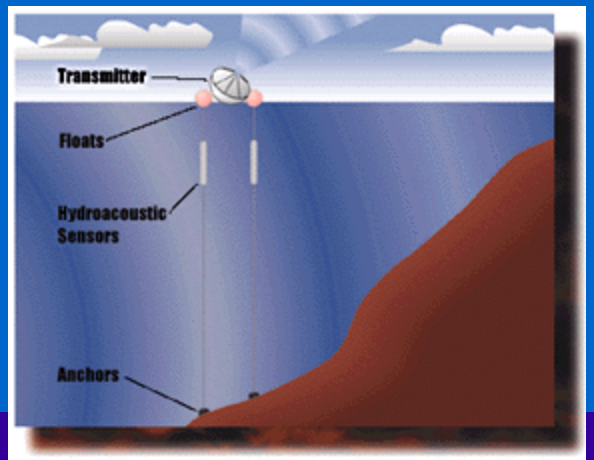


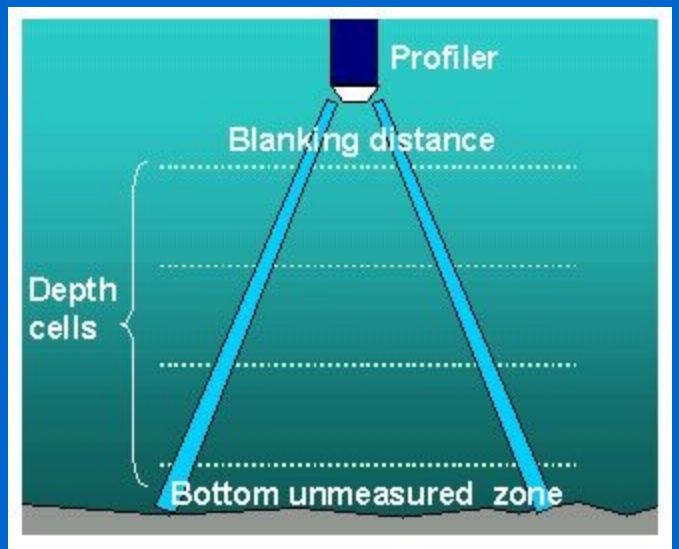
Advantages and Limitations: Advantages (cont.)

- Large bodies of water can be covered
- Eliminates all problems of sampling
- Little avoidance of acoustic signal by fish

Advantages and Limitations: Limitations

- Species cannot be identified
- Cannot easily sample all parts of the aquatic environment
- Fish near the surface (0.5m) cannot be easily detected



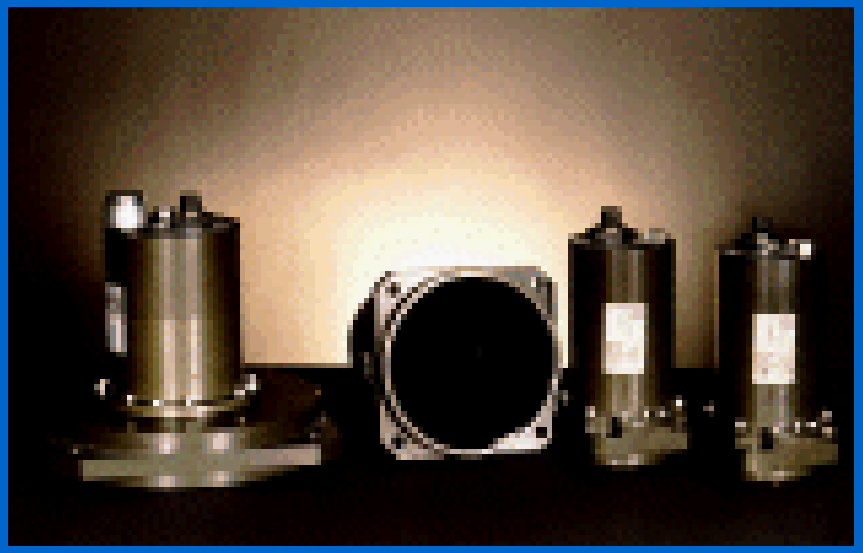


Advantages and Limitations: Limitations (cont.)

- Maximum depth of sampling limited as sound loses energy with depth
- Trained personnel are required to operate acoustic equipment

13.2 Components of Underwater Acoustics

- Sound Transmission
- Echo Production and Sound Reception
- Data Display and Analyses

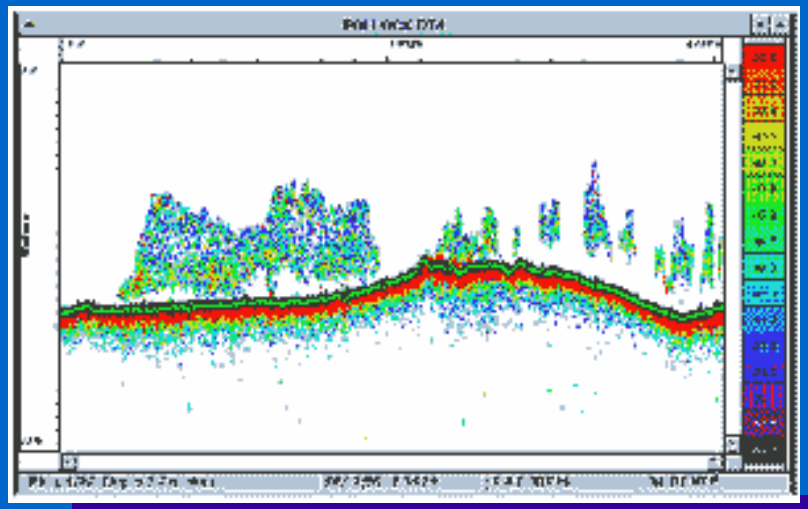


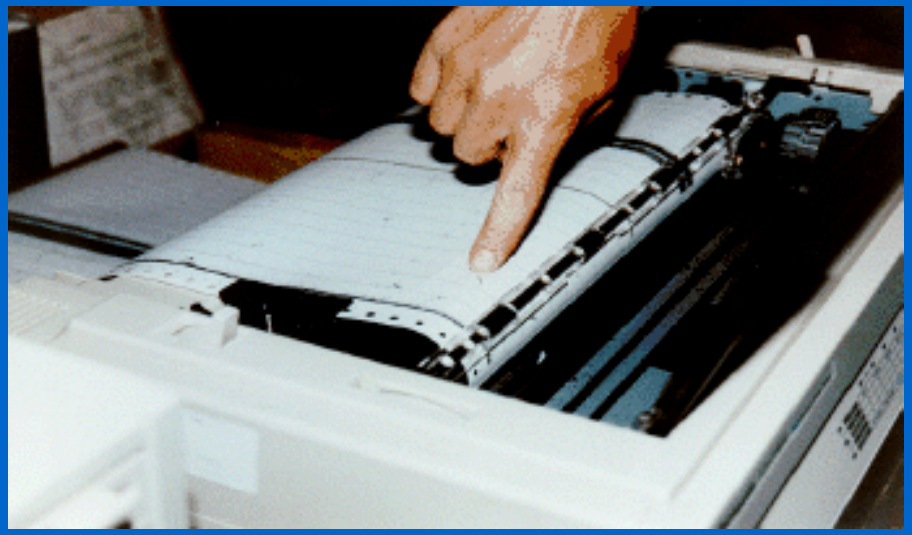
Sound Transmission

- Sound into water as pulse
- Sound encounters targets...fish
- Sound reflected back toward source
- Echoes provide
  - Fish size
  - Location
  - Abundance

Basic components of acoustic hardware

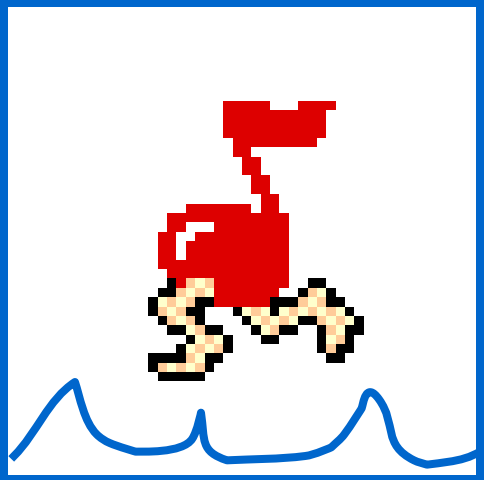
- Transmit sound
- Receive
- Record
- Analyze echoes





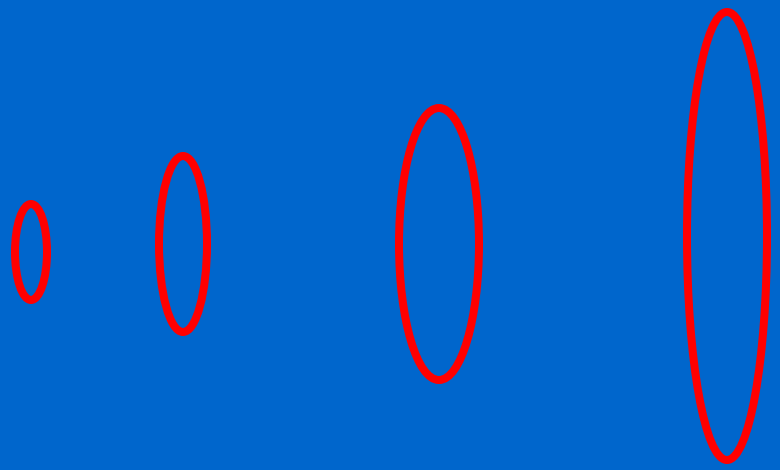
Echo Production and Sound Reception

- Pressure wave
- Periodic expansion and contraction of water
- Speed of 1500m/s in salt water



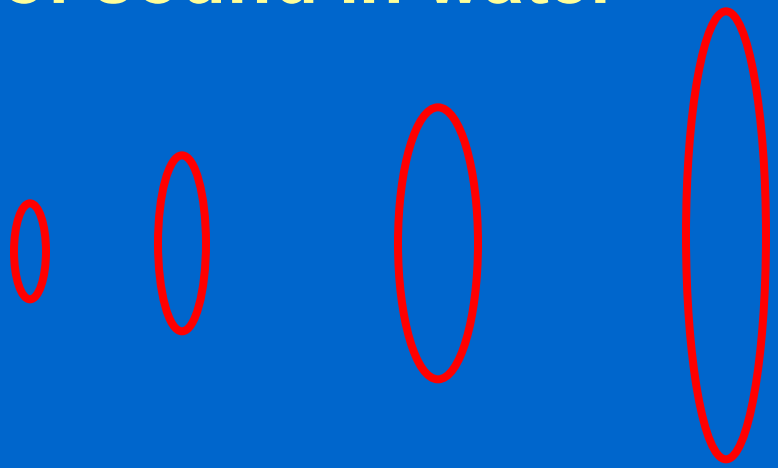
Echo Production and Sound Reception (cont.)

- Acoustic sampler listens for echoes
  - Get echoes from all objects with different density than water
  - Fish swim bladders good targets



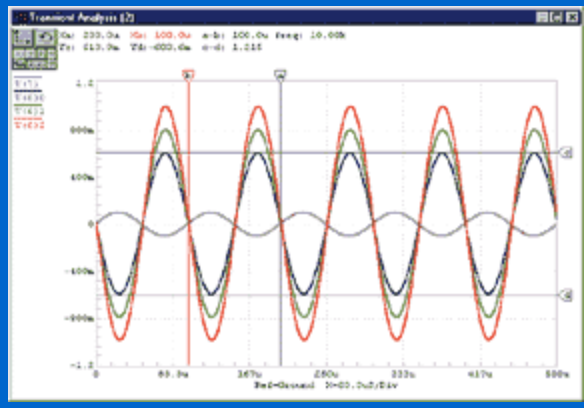
Data analysis and display

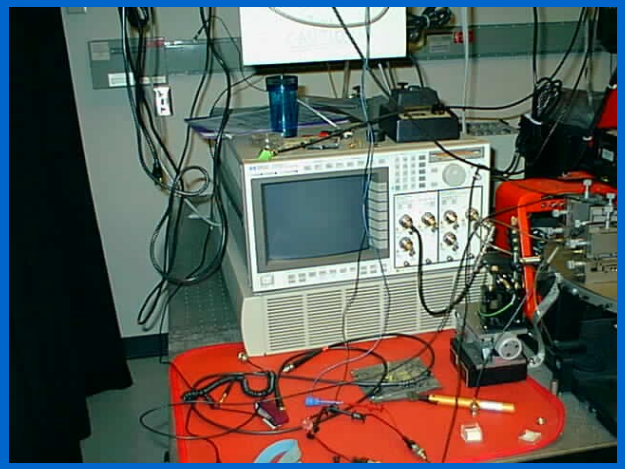
- Length of time between sound and echo is determined by
  - Distance of acoustic target from transducer
  - Speed of sound in water



Data analysis and display (cont.)

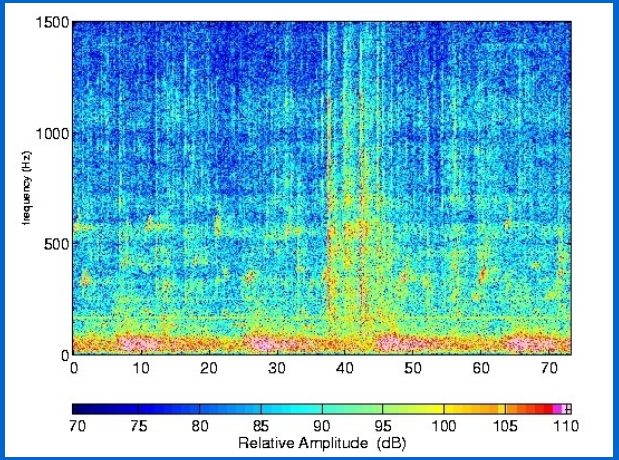
- Size and number of echoes = fish size and abundance
- Echo voltage monitored on oscilloscope

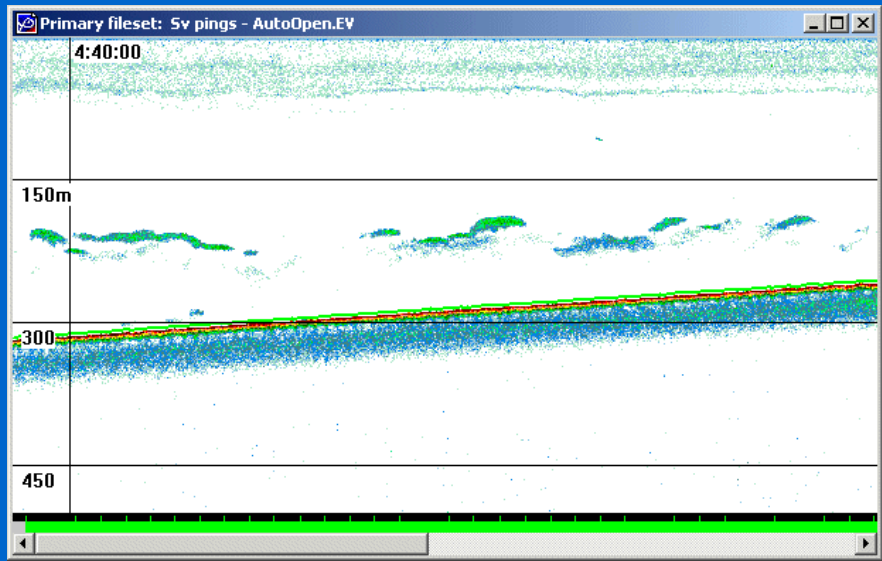




Data analysis and display (cont.)

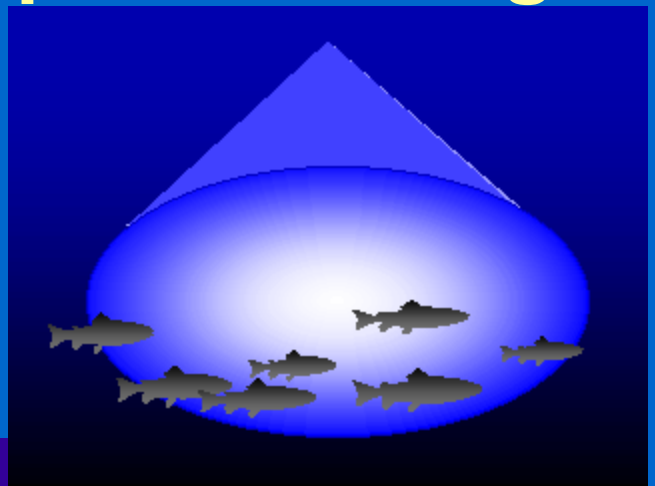
- Displayed graphically on chart recorder
- Chart recorder produces marks
- Map produced known as echogram





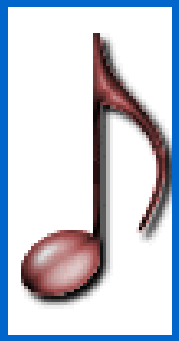
13.3 The Sonar Equation

- Mathematically describes sound transmission and reflectance in water
- Expressed in sound pressure, voltage amplitude or logarithmic form



Decibel

- Unit used to express logarithmic differences in sound intensity
- Dimensionless unit based on ratio of sound intensities
- Defined as 10 • Log10(Ia/Ib) Where Ia and Ib are two different sound intensities



The Sonar Equation (cont.)

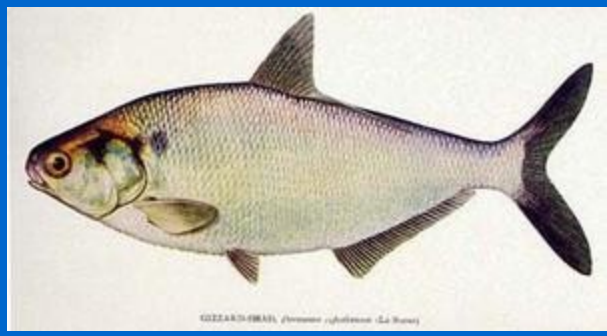
- Echo returning depends on amount of sound reaching target
- Sound intensity drops rapidly at increasing angles from acoustic axis
- Sound not transmitted uniformly in all directions from transducer surface
- (For equations, refer to page 393-394)

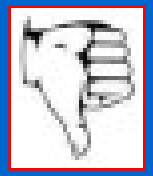
Preparation for Fish Stock Assessment

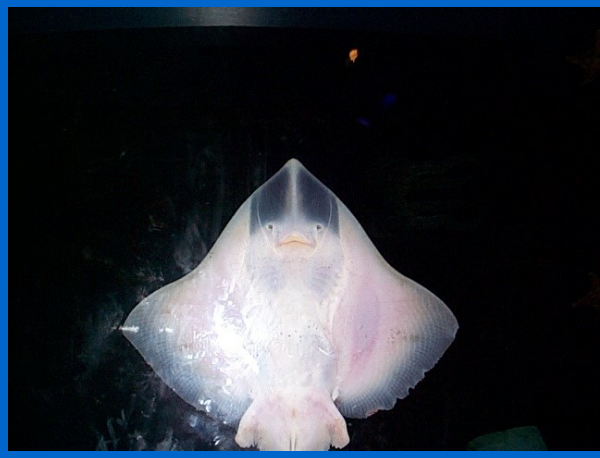
- Most common application of underwater acoustics

Evaluation of Objectives

- Assess if acoustic is appropriate for objectives
- Not suitable for all species or environments
- Good for mid-water species
- Determine the type of data needed

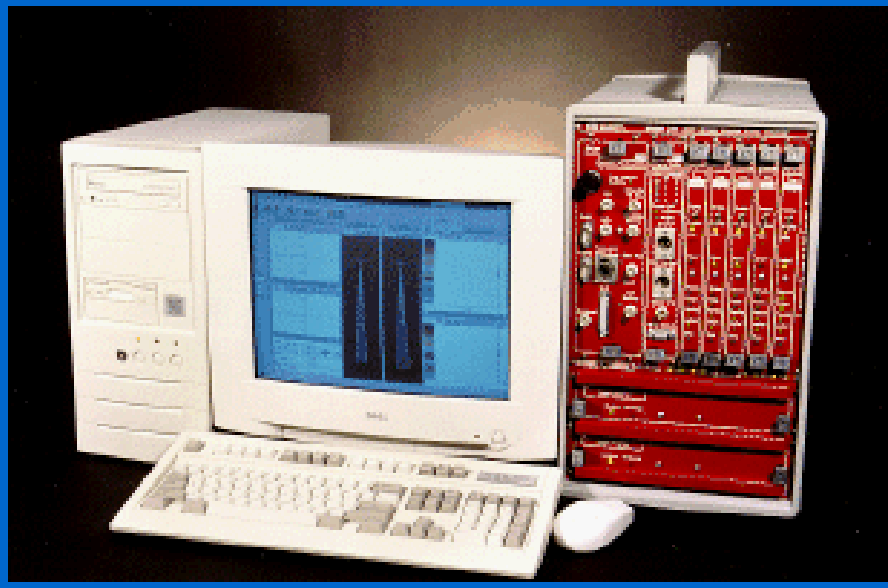






Selection of Acoustic Hardware

- Require measurements made with
  - Scientific quality echo-sounder
  - Sounder with stable electronics and low noise levels
  - Easily calibrated sounder

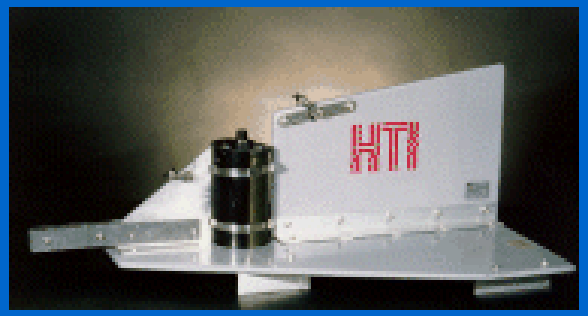


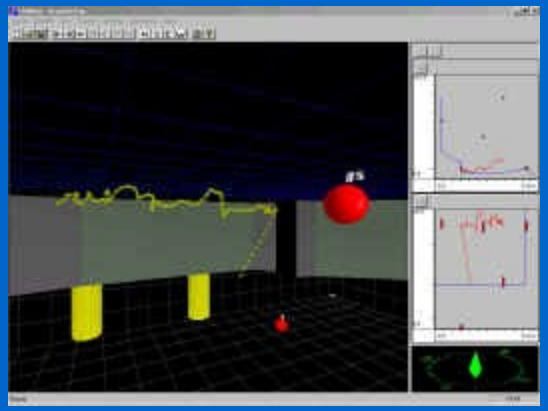
Choice of acoustic hardware depends on

- Type of questions asked
- Whether relative or absolute densities needed
- Size and distributions of fish
- Type of transducer deployed
- Physical characteristics of aquatic environment

Primary considerations for technical factors

- Frequency
- Spatial resolution
- Pulse transmission rate
- Other electronic equipment needs



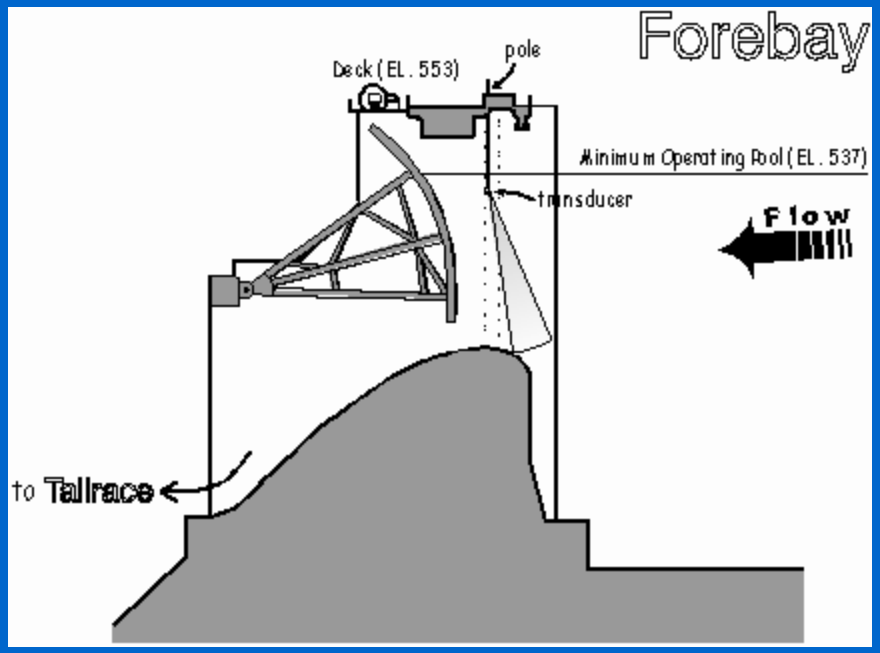


Transducer type and deployment

- Pressure sensitive device generating voltage when pressure/voltage applied
- Come in different sizes and materials
- Selection of transducer and echo sounder go hand in hand

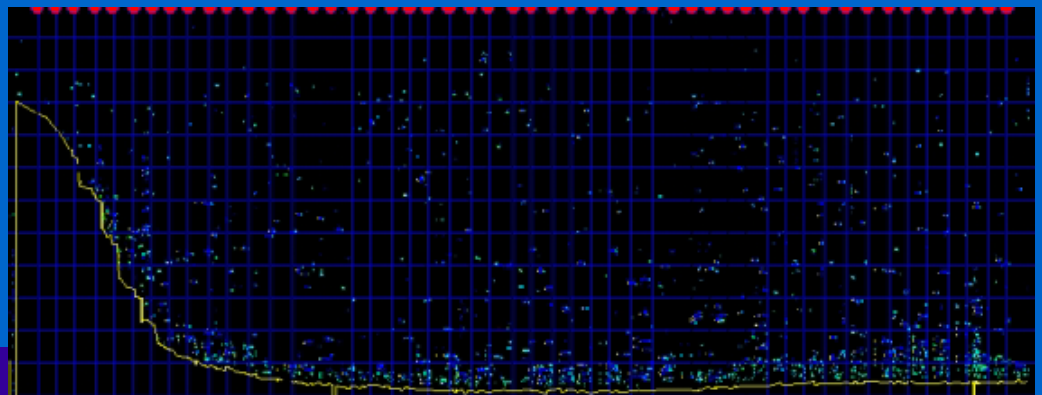
Transducers can be deployed in a several ways

- Fixed in one place
- Towed through the water facing
  - Upward
  - Downward
  - Off the side
- Mounted through the hull



Survey design

- Objective is to sample representative part of population
- The design must
  - Cover geographic extent of population
  - Take into account behavior and distribution of fish

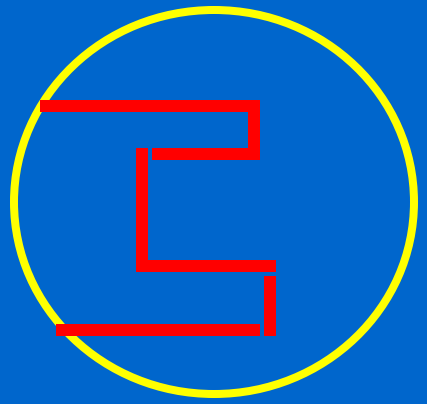


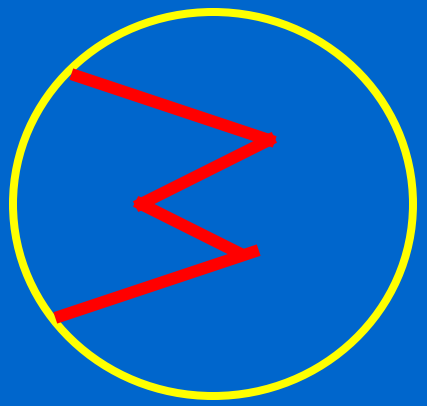
Survey design (cont.)

- Surveys are generally more effective when fish are:
  - In the middle of the water column
  - Dispersed
  - Relatively isolated from other species

Survey design (cont.)

- Commonly used survey designs:
  - randomized
  - parallel
  - zigzag
  - box transects





Additional sampling requirements

- Physical and chemical measurements across sample area
- Biological sampling
- Acoustic calibration
- Measurements of fish target strength

Calibration

- Critical for quantitative measures of absolute densities and sizes of targets

Calibration (cont.)

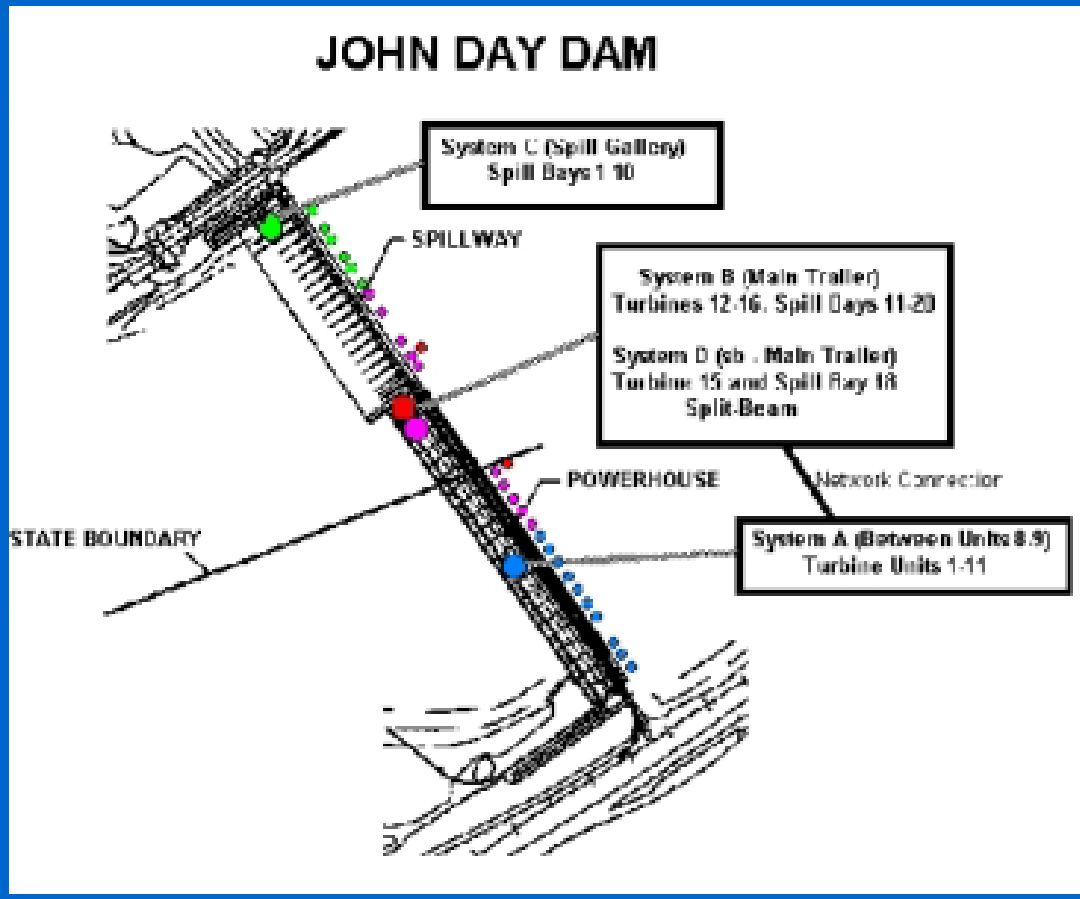
- 3 procedures
  - regular measurements of sounds source levels and directivity patterns
  - use standard targets to measure hardware performance
  - use measure recording levels and echo sounder amplification

13.5 Applications of Acoustics to Fish Stock Assessment

- Fish abundance estimation
- Fish target strength
- Measurements of fish size & biomass
- Population abundance estimations
- Sampling variance
- Bias and noise in the data
- Species identification

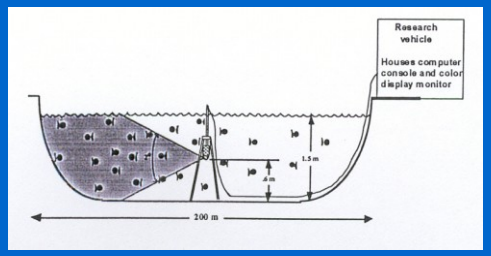
13.6 Additional Applications of Acoustics

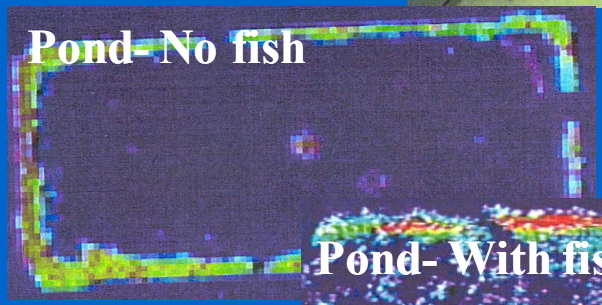
- Fish ecology
- Fixed-location transducer deployment
- Invertebrate assessment

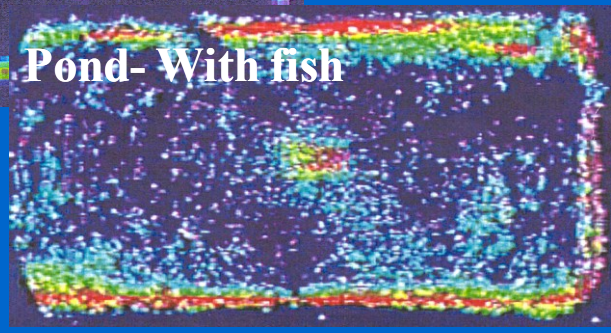


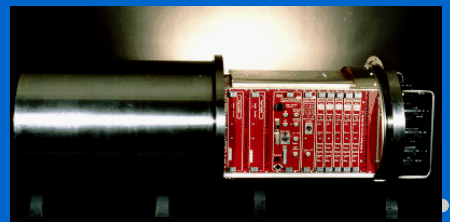
13.7 Developing Technologies

- Developments
  - Geostats
  - (GIS)
  - Ecological modeling
- Transducer deployment strategies
  - Side sonar
- Multifrequency echo sounders
  - Separate fish from invertebrates









13.8 Training

- Need specialized training
- Short courses available to learn operation of equipment and basic concepts (http://www.htisonar.com/training.htm)
- However, in-depth training needed for survey design, analyses, and interpretation of data