The Evolution of Fisheries Acoustics

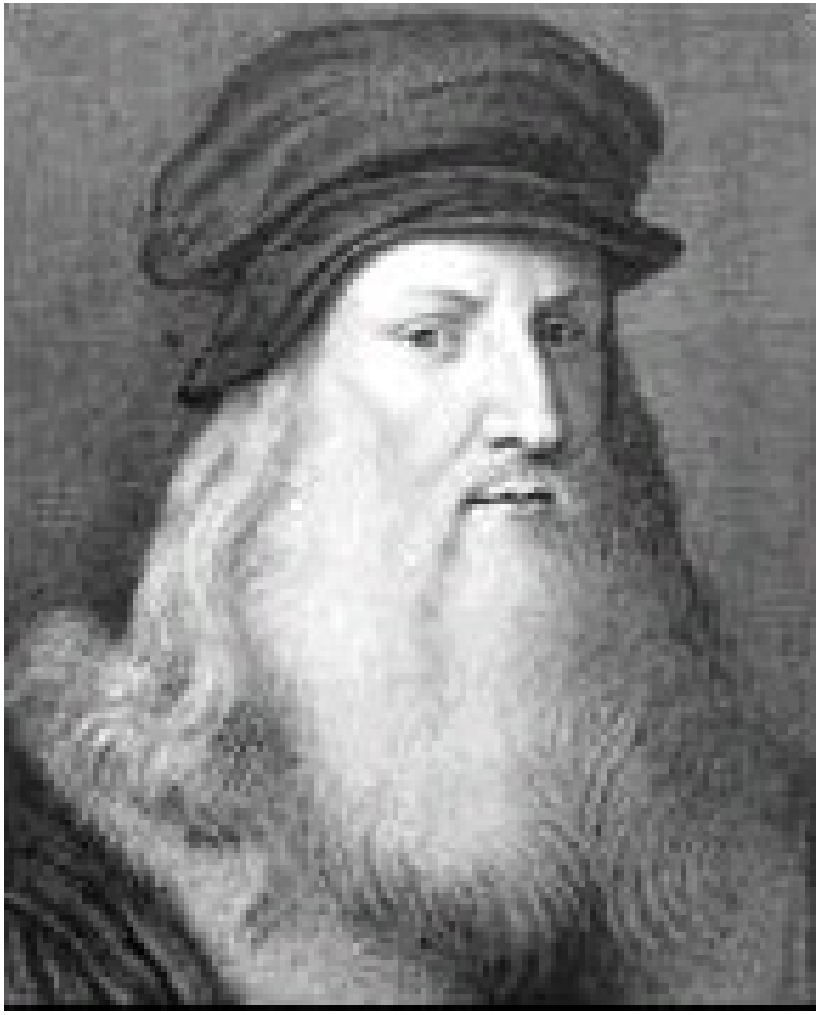
LO: Identify and sequence hardware and analytic contributions made to Fisheries Acoustics.

The First Sonars

Sperm whale (*Physeter macrocephalus*)

Killer whale (*Orcinus orca*)

Underwater Sound



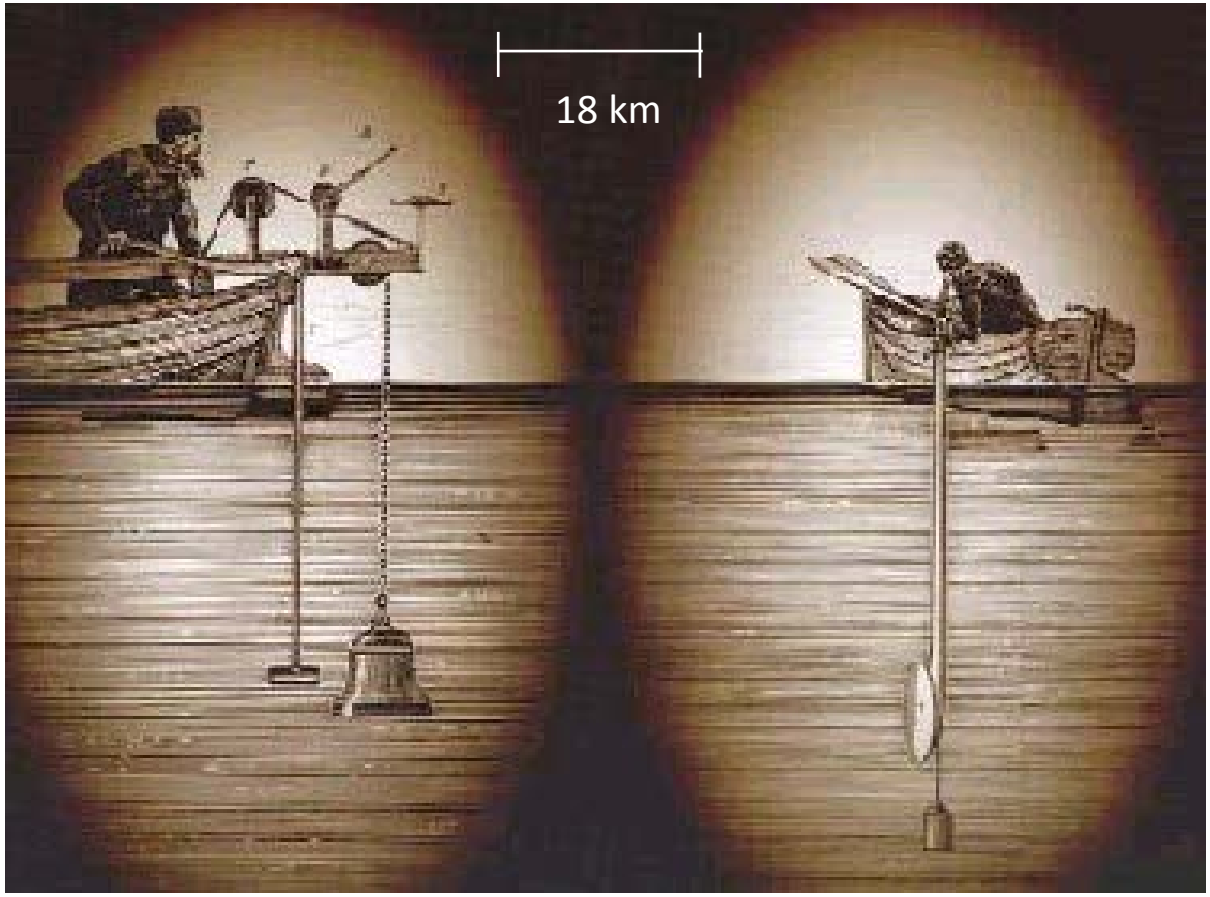
Leonardo da Vinci (1490)

using a tube…

‘you will hear ships at a great distance’

Measuring Speed of Sound

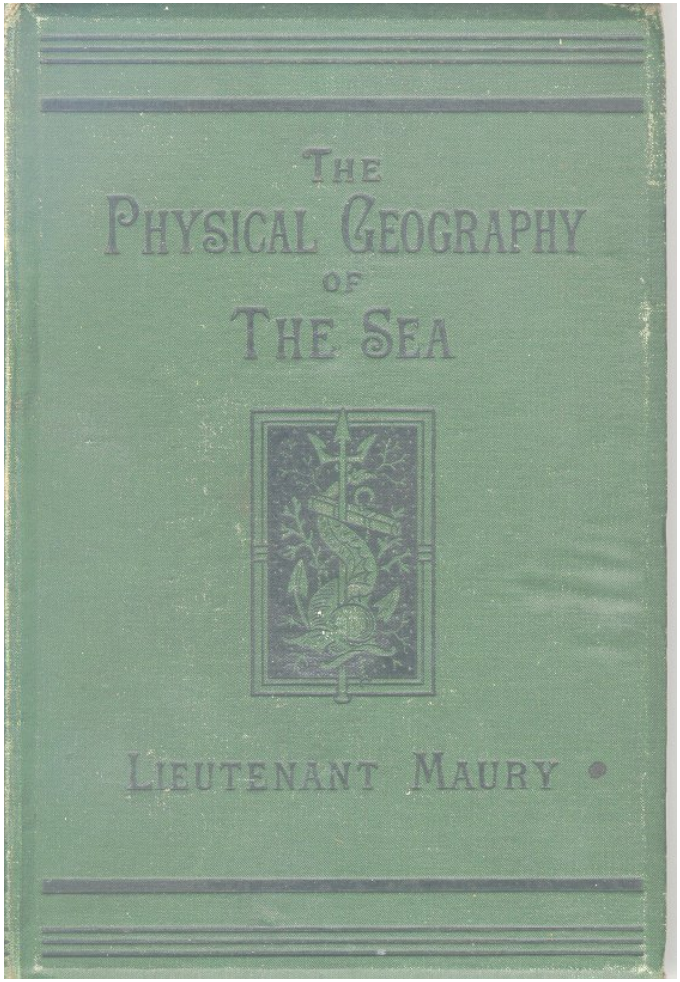
Colladon and Sturm (1826), Lake Geneva, Switzerland



Sound speed estimate: 1435 ms^{-1}

Δ = 4 ms^{-1} from current values

20th Century Use of Sound



To ‘fathom the ocean’

Lieutenant Maury,US Navy (1859)

Making Echosounders Practical

Piezoelectric transducer (1917)

French Physicist: Langevin

(piezo = pressure)

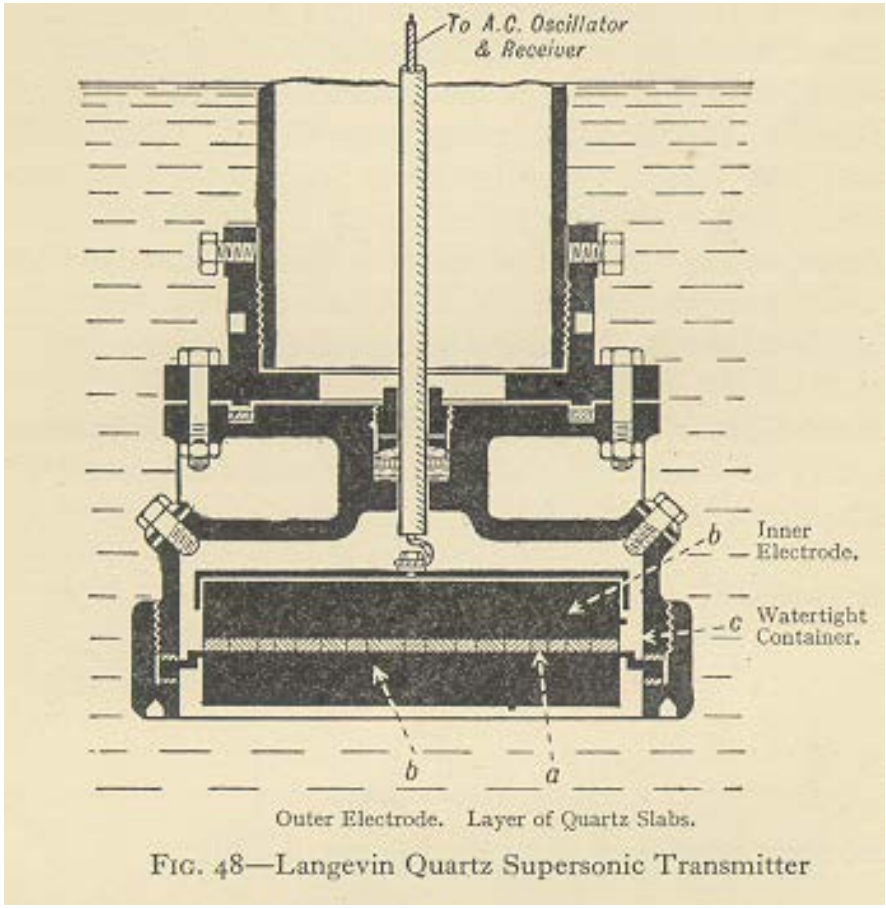


FIG. 48—Langevin Quartz Supersonic Transmitter

1925: ‘echo sounding’ first used in scientific literature

Making Echosounders Practical

Belloc (1929):

Langevin-Florisson echosounder

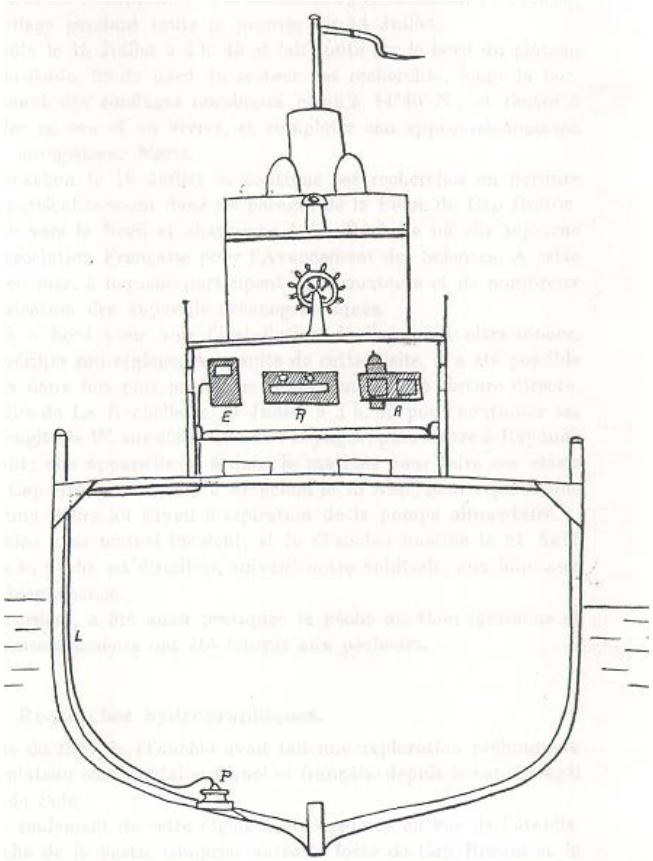


Fig. 7

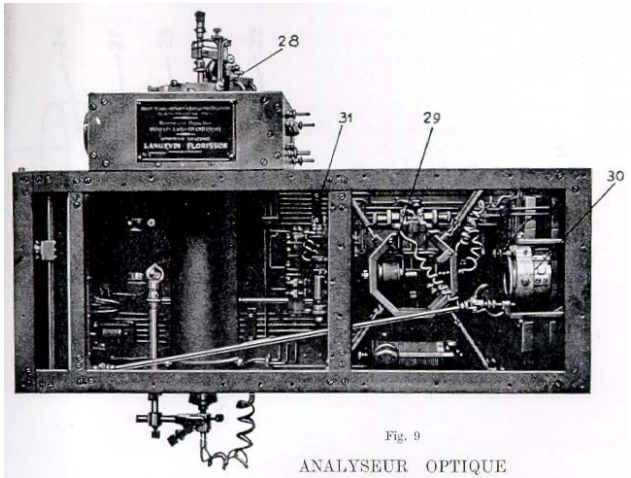
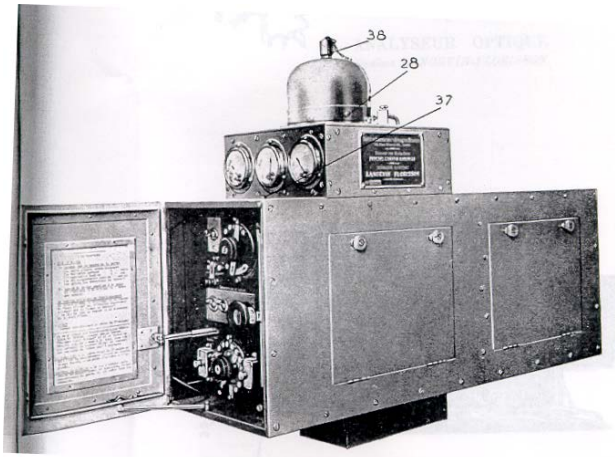
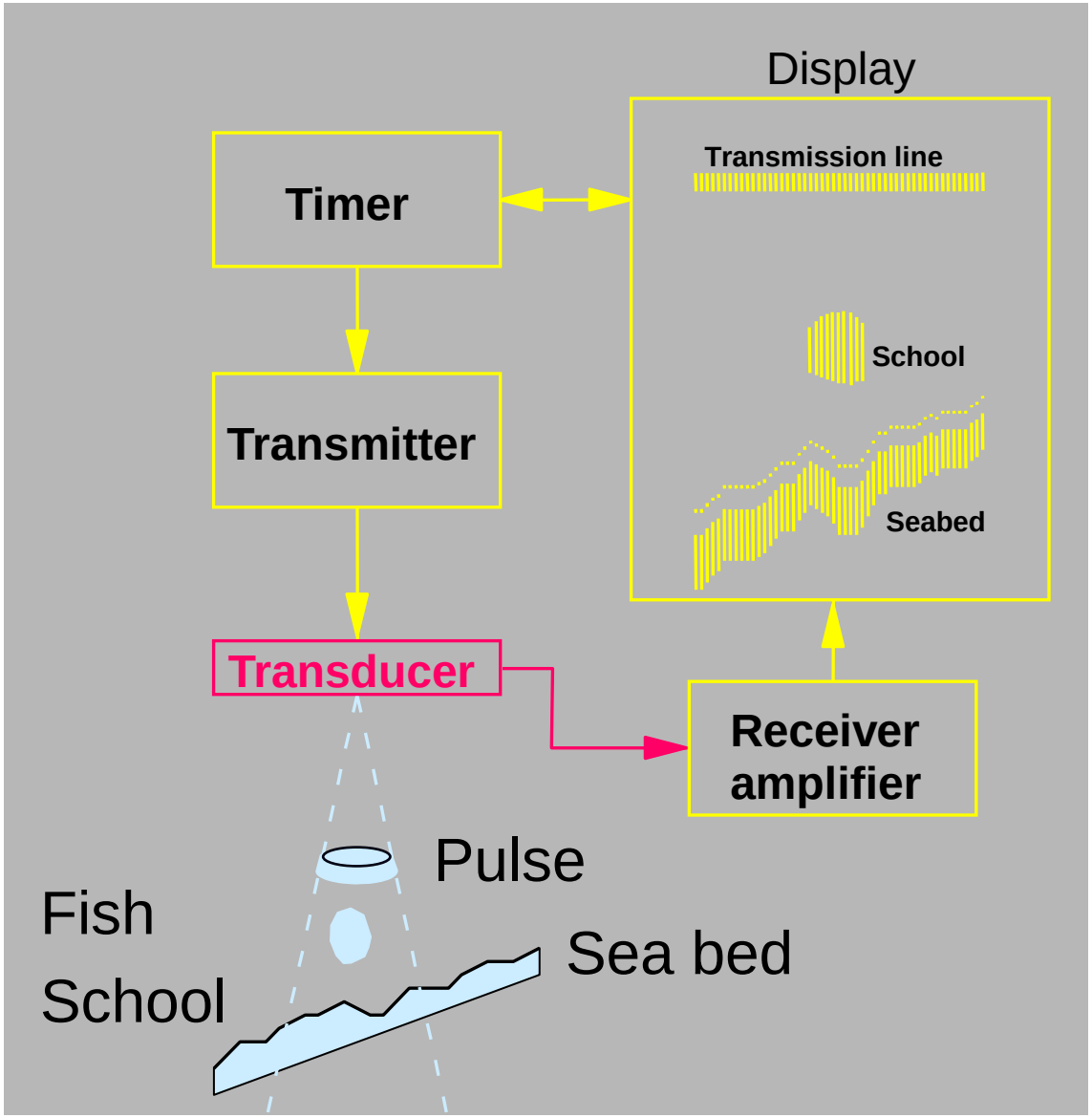


Fig. 9

ANALYSEUR OPTIQUE



The Echosounder



Acoustic Detection of Fish

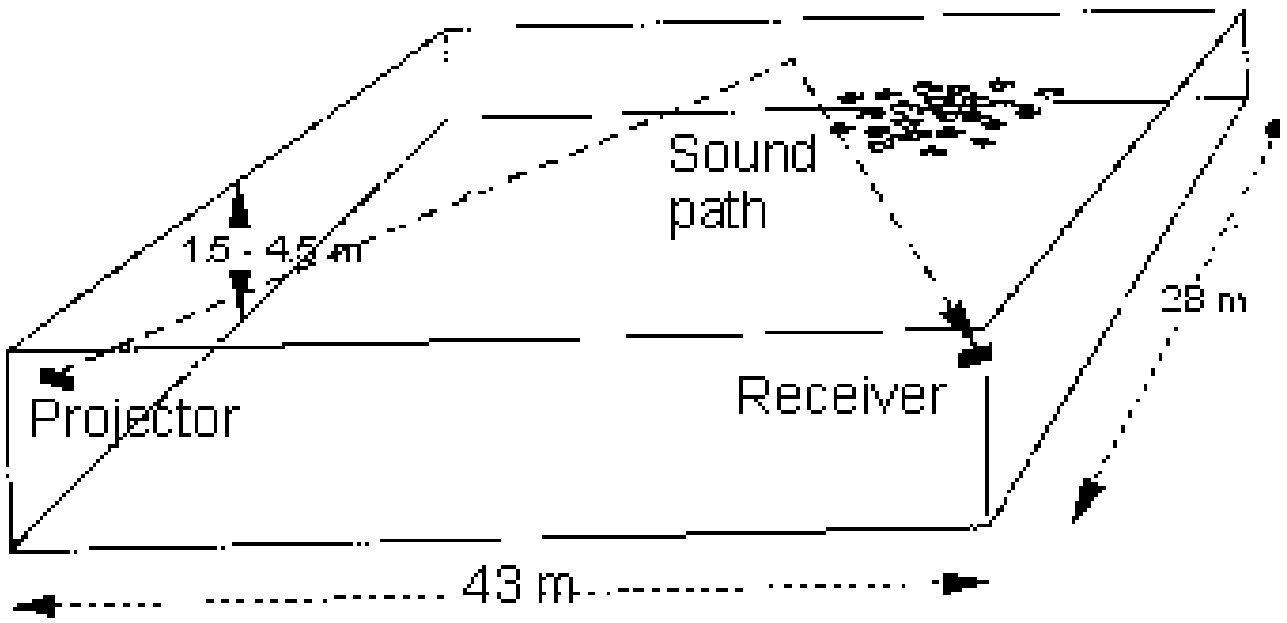
Rallier du Baty:

1927 – ‘false’ signals on echosounder to cod shoal on Grand Banks

1928 – detected herring on a Bologne drifter

1st Lab Acoustic Fish Detection

Kimura (1929)



Bistatic sonar: source and receiver

Fish as Acoustic Targets (1930s)

Sund (1933)

“Herring false echoes”

Fish aggregations causing bottom like echoes

Fish as Acoustic Targets

Ronald Balls, Skipper of
Violet and Rose

The Marconi "North Sea" type of Echometer used by Mr. Balls

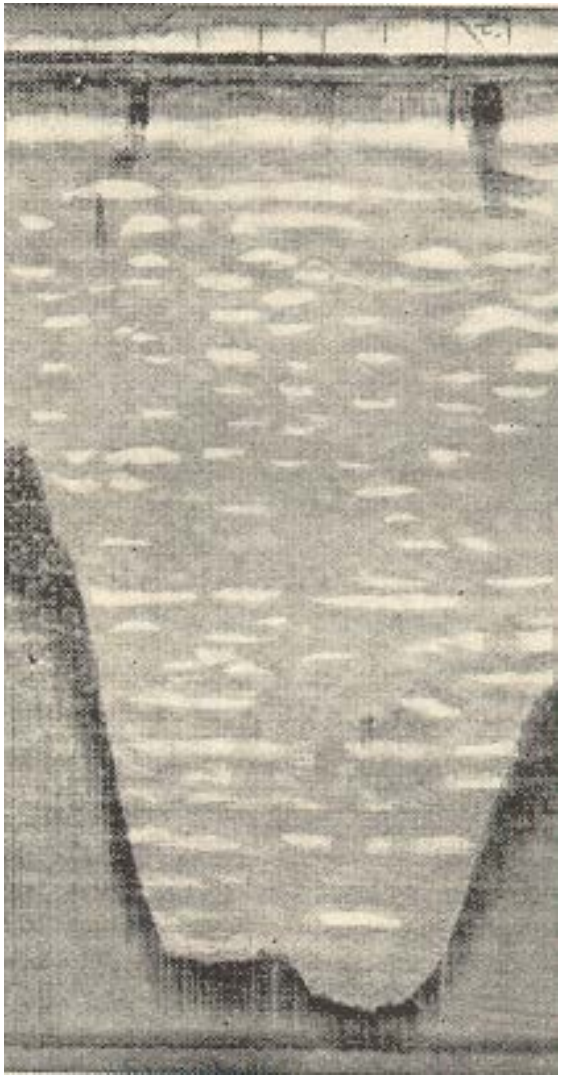
7 years fishing: a Marconi echometer

Recording Echosounder

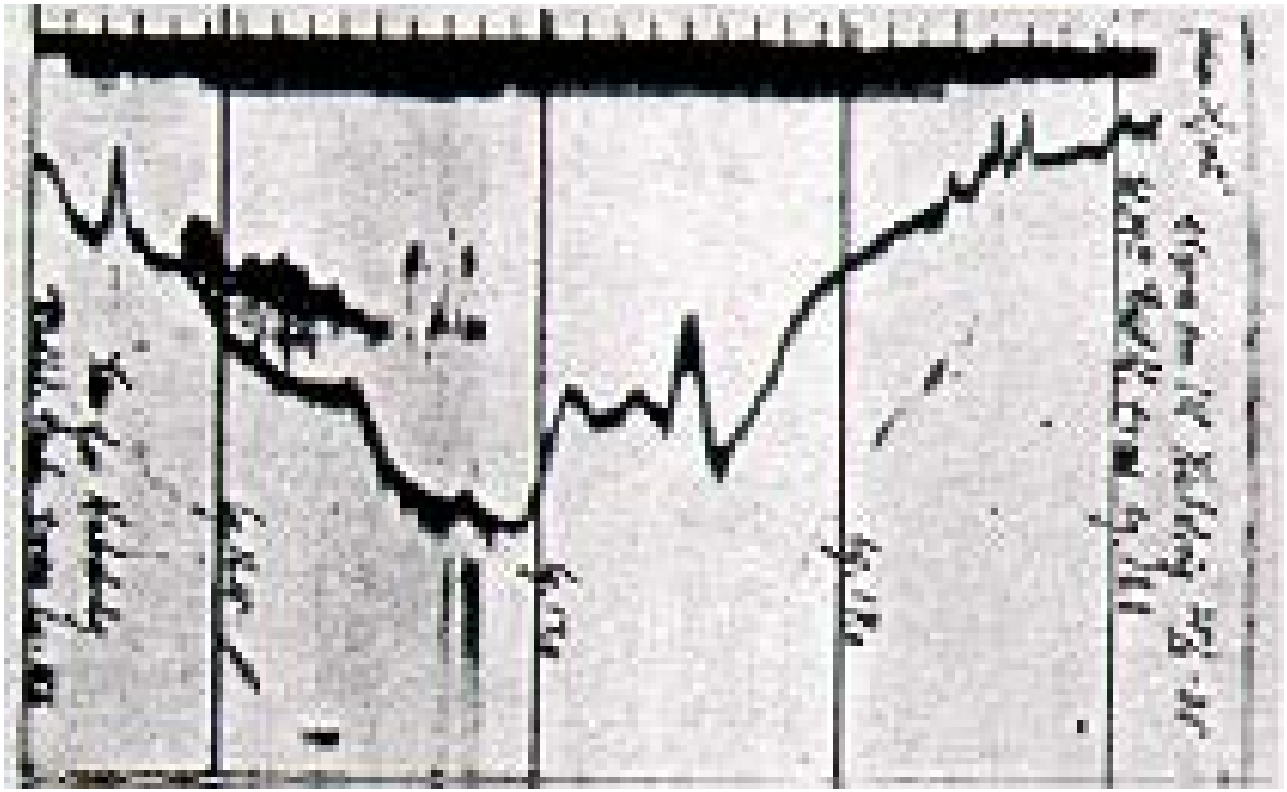
Wood et al. (1933) marketed by Hughes

- first published echogram: Bokn (1934)

- sprat schools near surface



1st International Publication



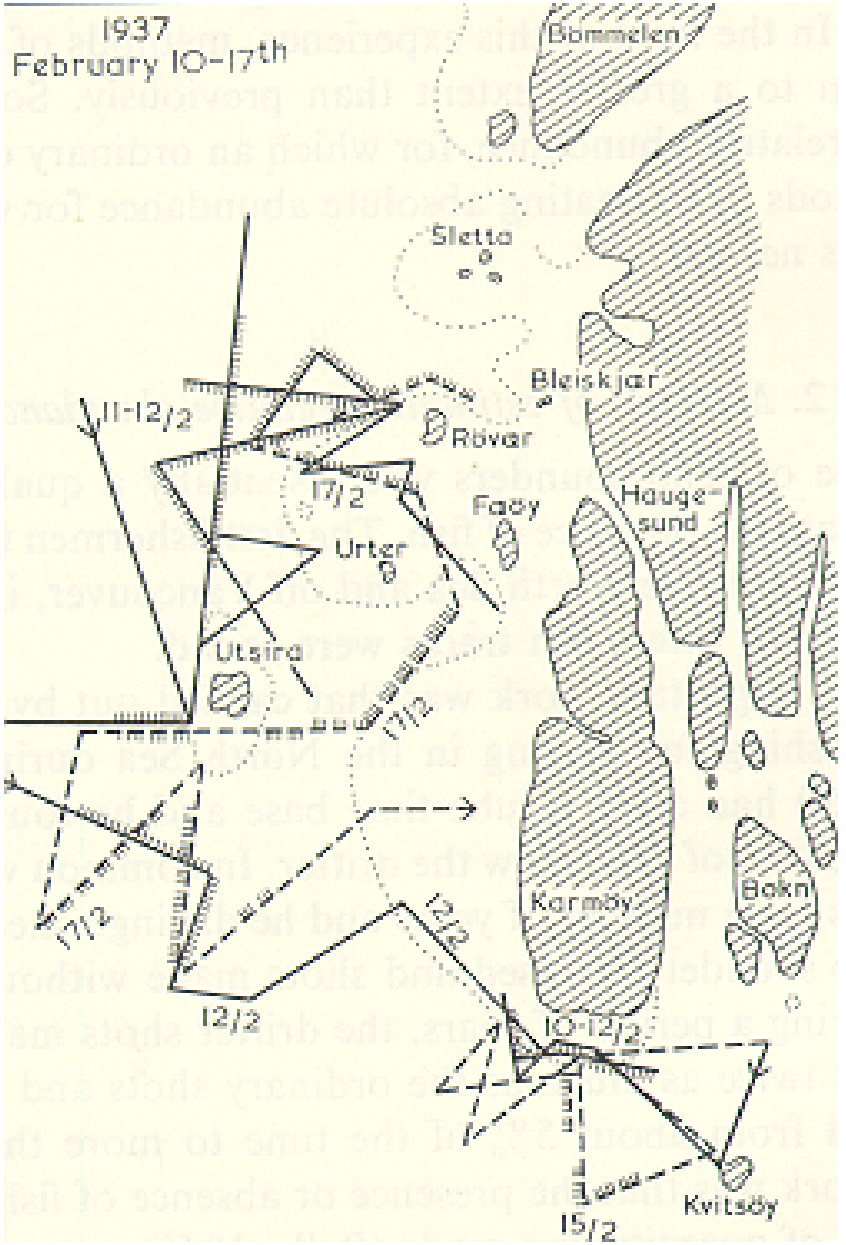
Sund (ICES 1935)

Echogram of cod in Vestfjord, Norway

Dedicated Acoustic Survey

Runnstrøm (1937)

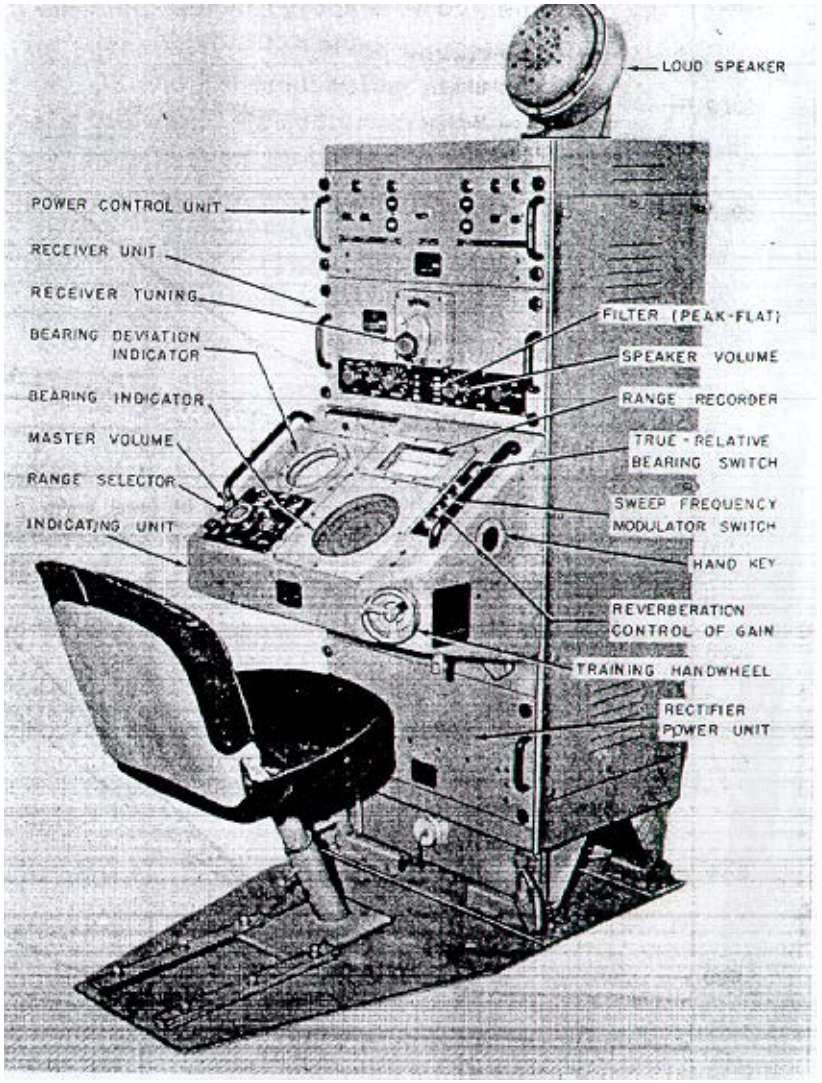
- herring surveys in Norway



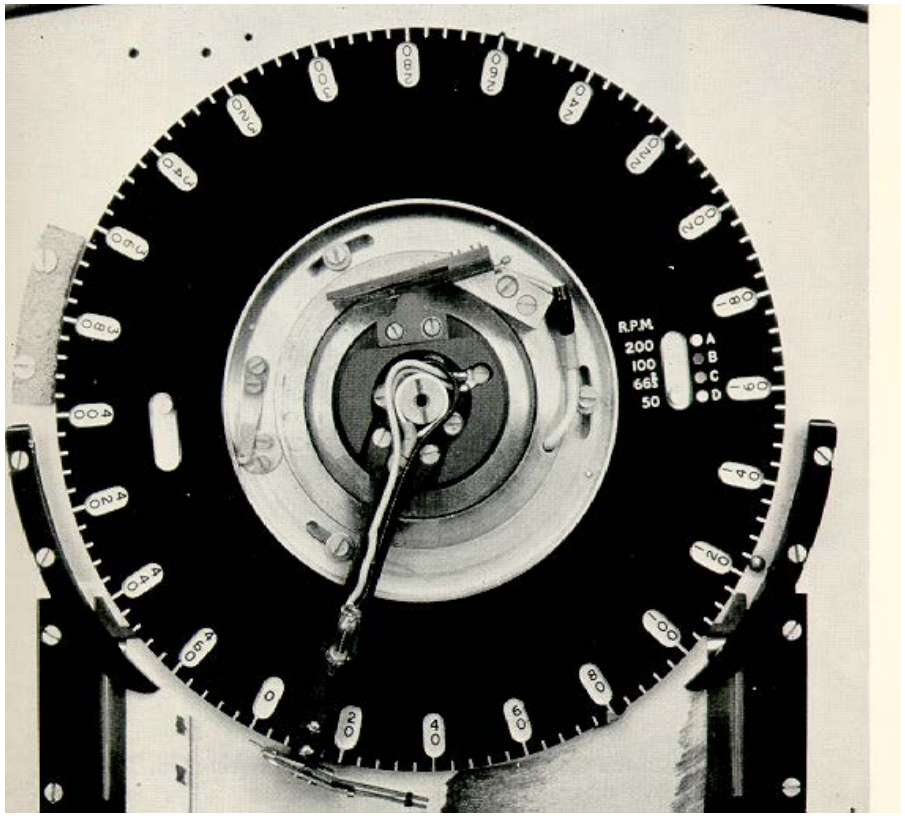
Introduction of SONAR

1940s: WWII

Sound Navigation and Ranging



Access to Technology (1940s)



M.S. XII (Kelvin & Hughes)

Ball's Report (ICES 1948)

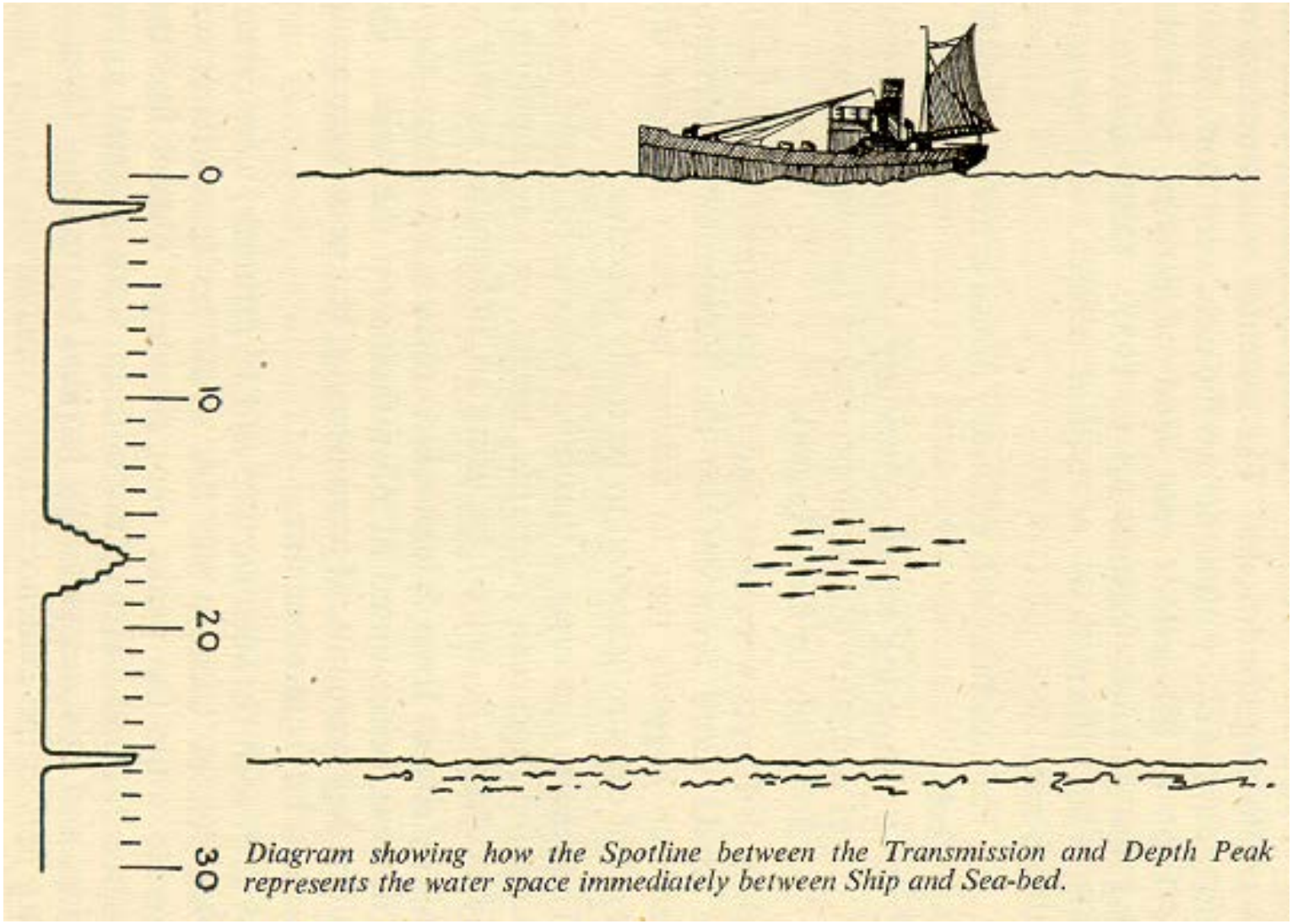
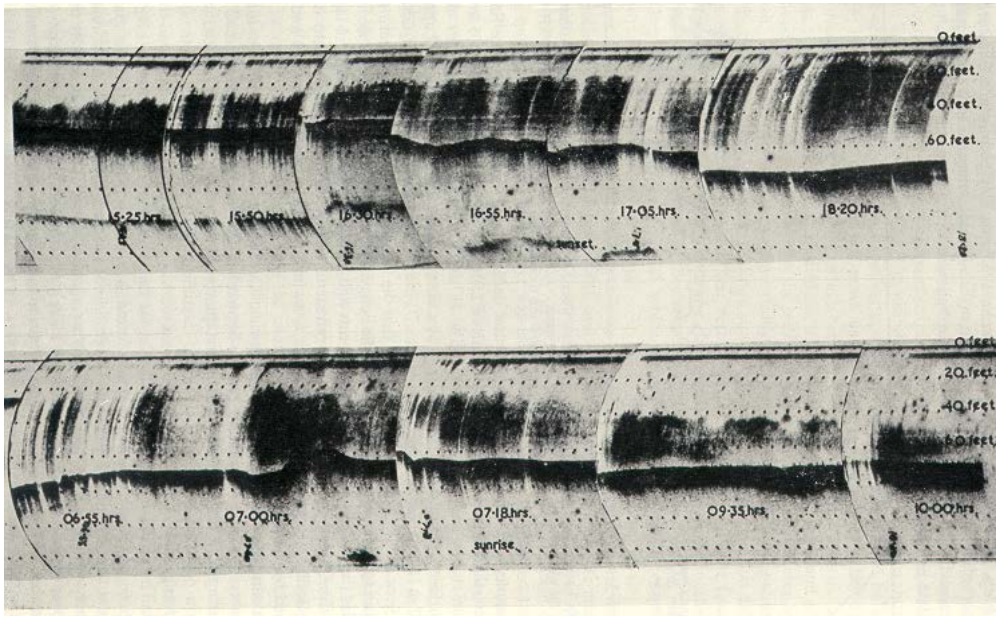


Diagram showing how the Spotline between the Transmission and Depth Peak represents the water space immediately between Ship and Sea-bed.

Correlation between marks in water and herring catch

Echosounder Applications

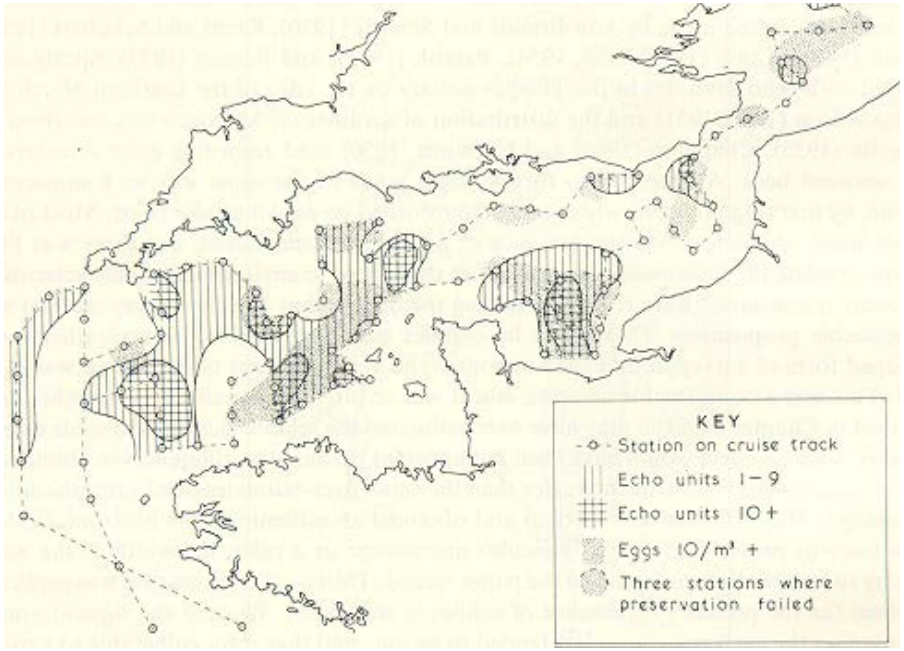


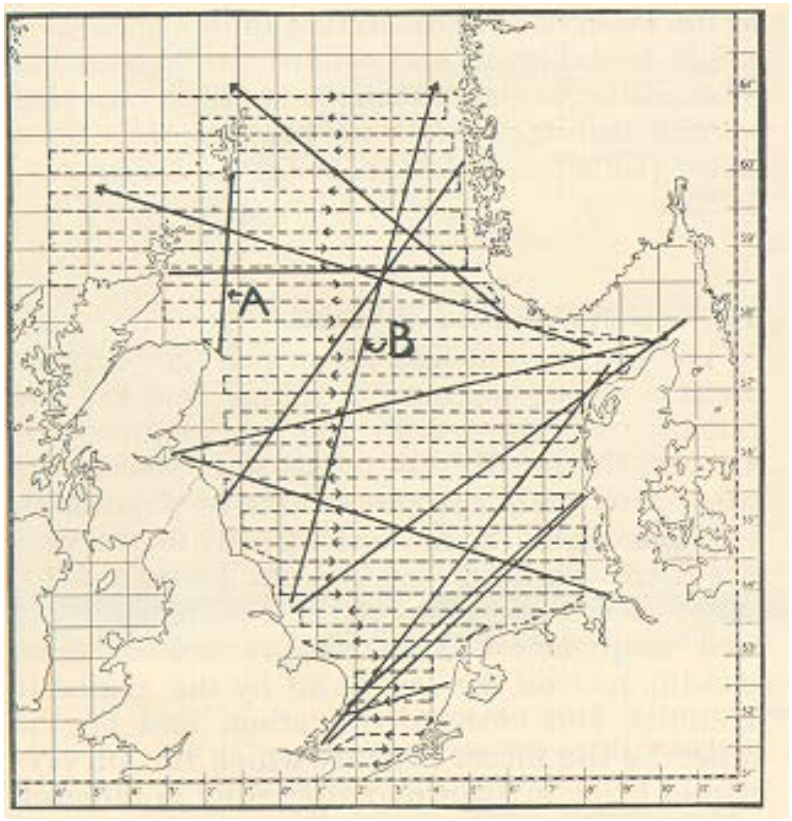
- Fish finding
- Gear monitoring
- Abundance surveys
- Plankton studies
- Fish behavior

Quantifying Acoustic Data (1950s)

- ICES Symposium:

  Echosounding as an aid to fishing
- Cushing (1952) echo units





Rationale for Sonar Need

Locating Icebergs:

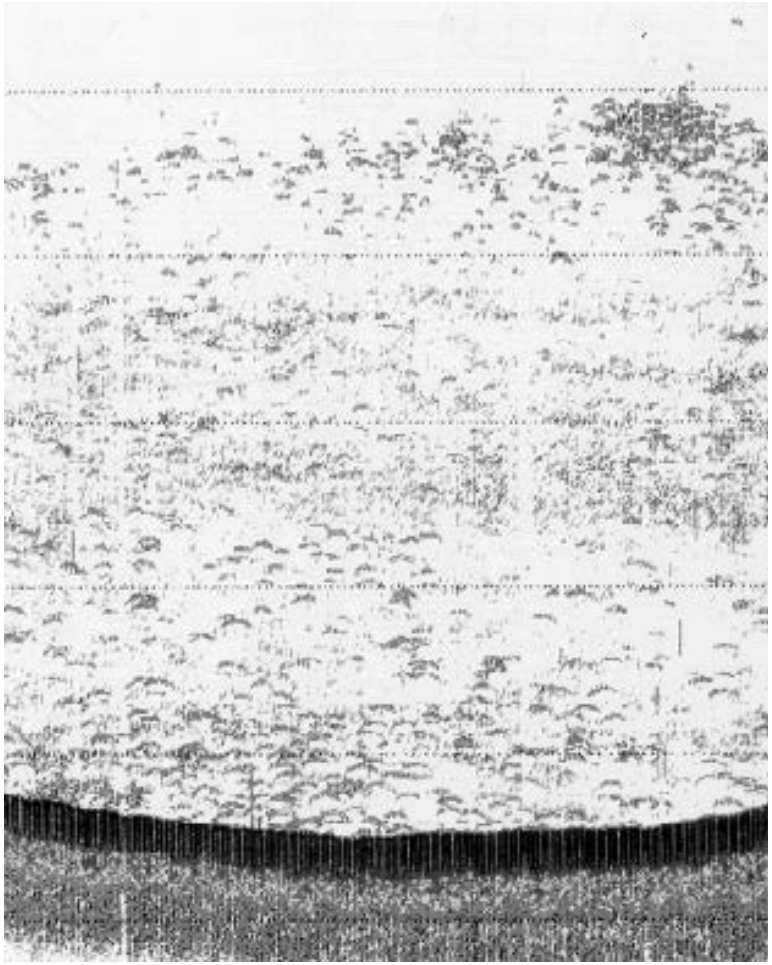
Titanic (1912)

WWI Detecting Submarines:

UK Anti-Submarine Division + ‘ic’ (ASDIC)

Quantifying Acoustic Data

- Trout et al. (1952)
  - suggested echo counting
- Hersey and Backus (1954)
  - frequency dependent scattering
- Middtun & Saetersdal (1957)
  - "Fingernail" trace
  - Echo counting
  - 1st absolute estimate
- Richardson et al. (1959)
  - Echo amplitude measurement



Technology Advances (1960s)

Automatic Counting Devices:

Mitson and Wood (1961)

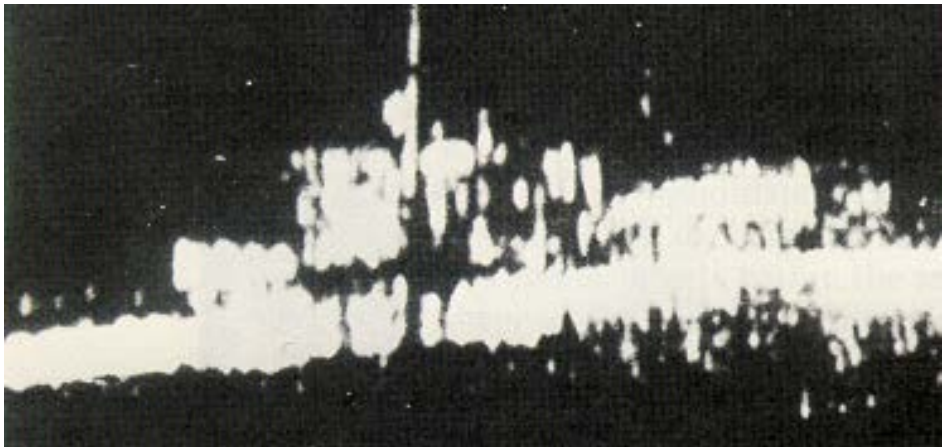
pulse counter

Craig and Forbes (1969)

pulse height analyzer

New instruments

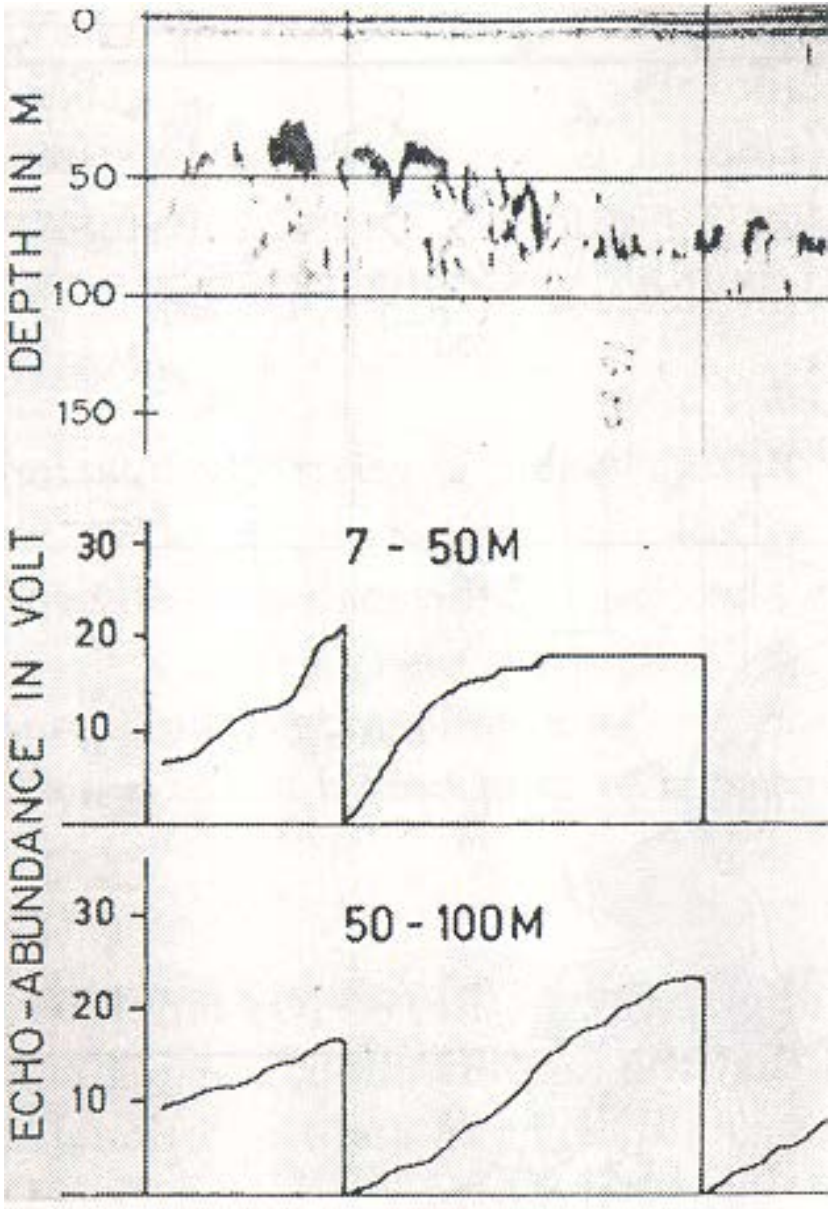
- Netsondes
- Side scan sonar
- Sector scanning



Analytic Advances

Dragesund and Olsen (1965)

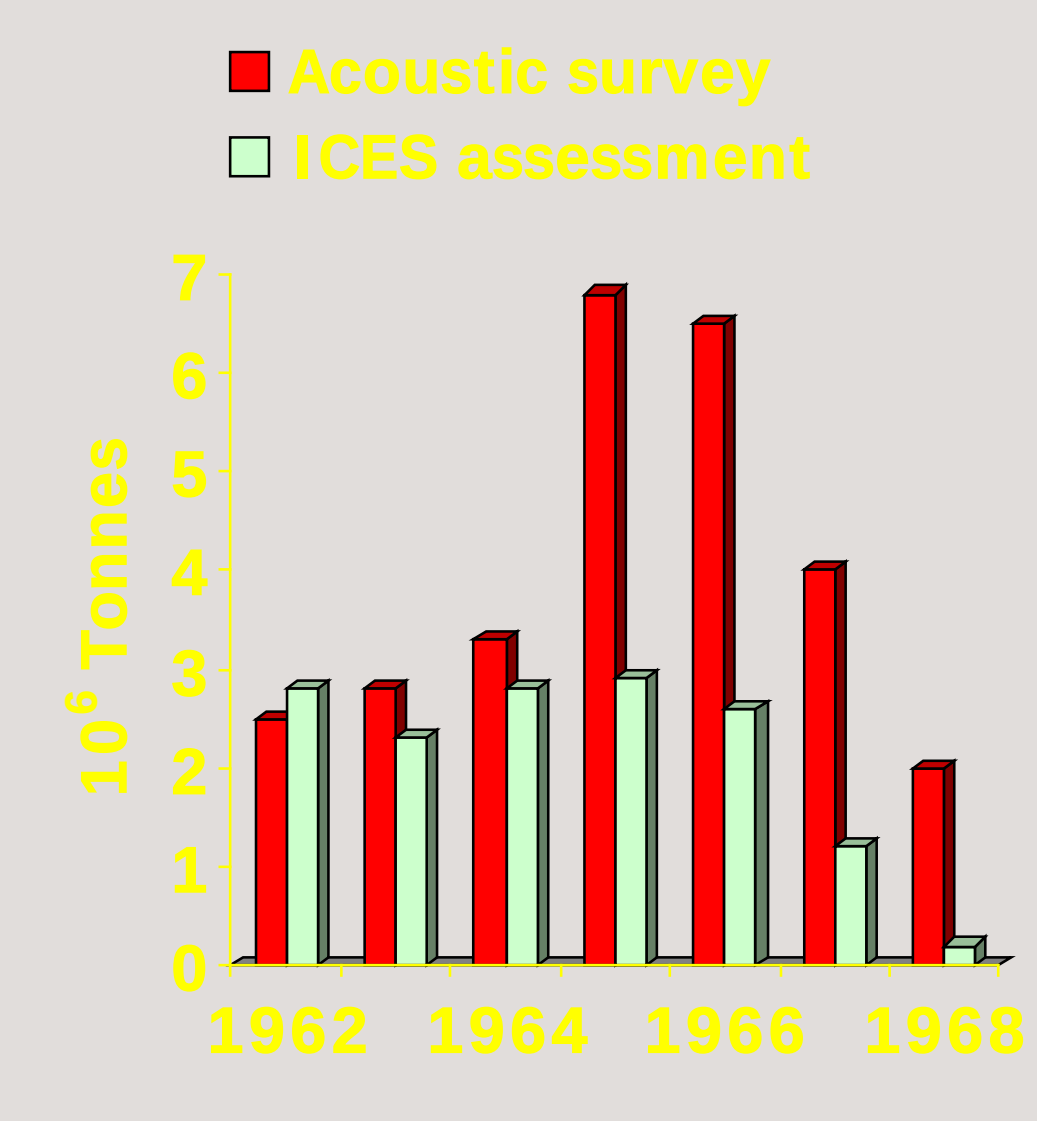
- echo integration



Validating Assumptions

Scherbino & Truskanov (1966)

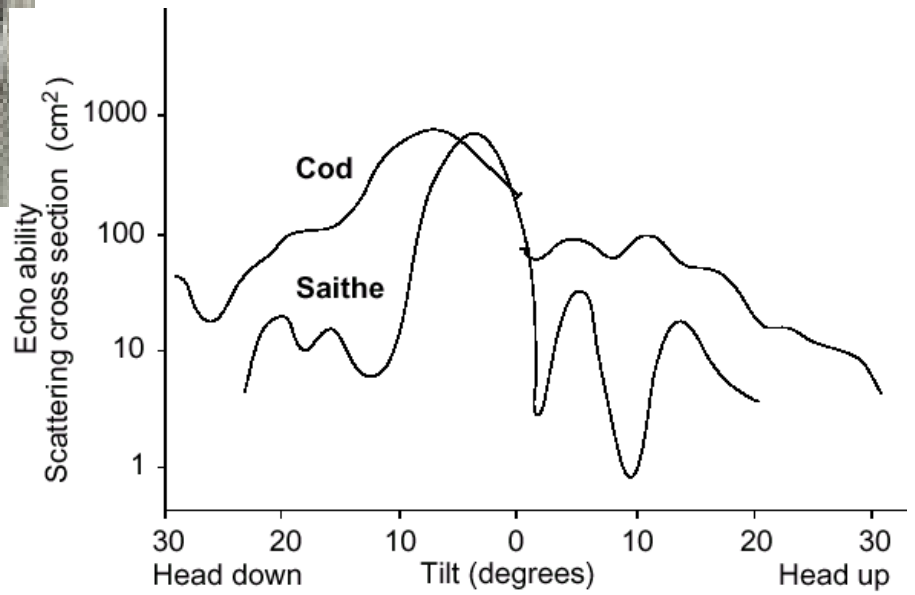
- absolute abundance estimate
- abundance $\propto$ squared echo voltage



Acoustic Biology

Middtun and Hoff (1962)

- acoustic properties of fish
- influence of tilt

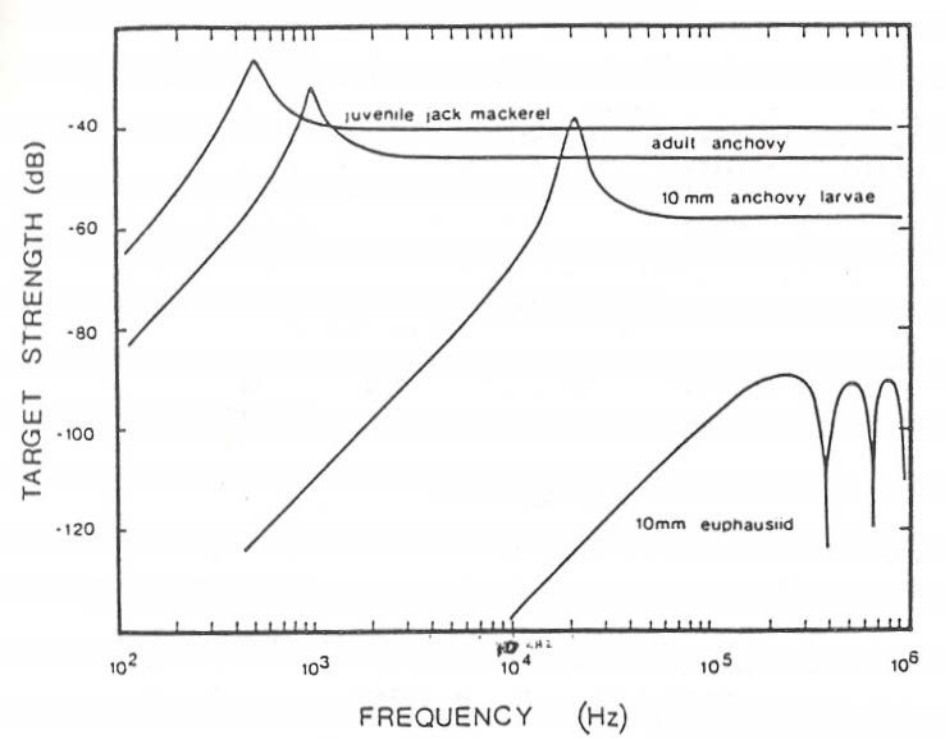


Exploiting Frequency Dependence

McNaught (1968, 1969)

- frequency dependence
- potential for inverse problem

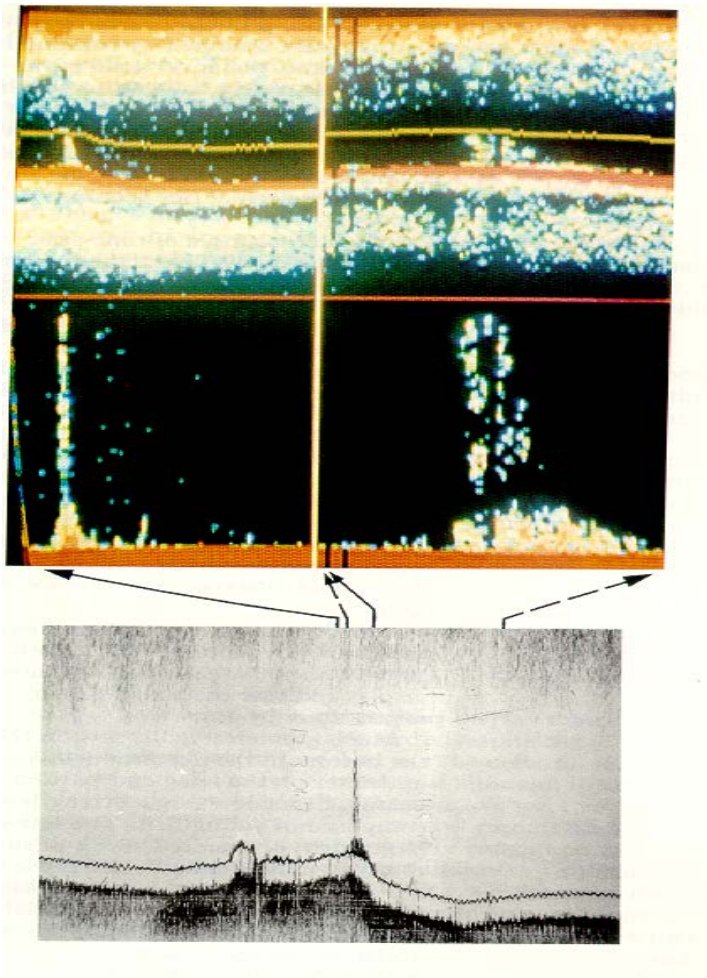
Holliday (1977) inverse algorithm



Digital Age (1970s)

Color displays

Digital electronics



New Hardware & Techniques

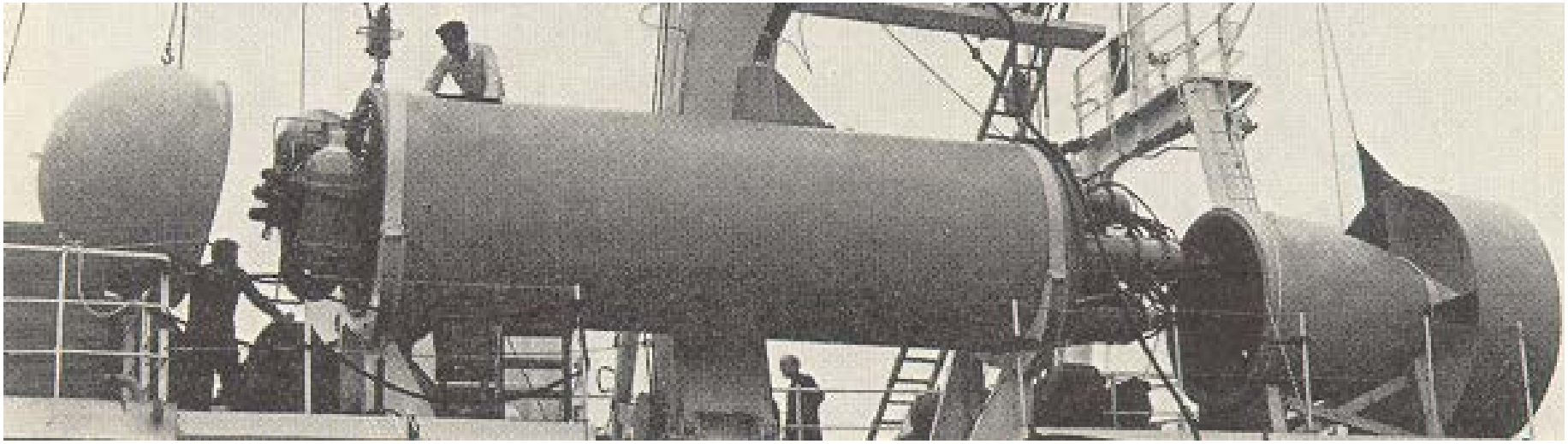
Transponding fish tags

Doppler effect

Multiple frequencies

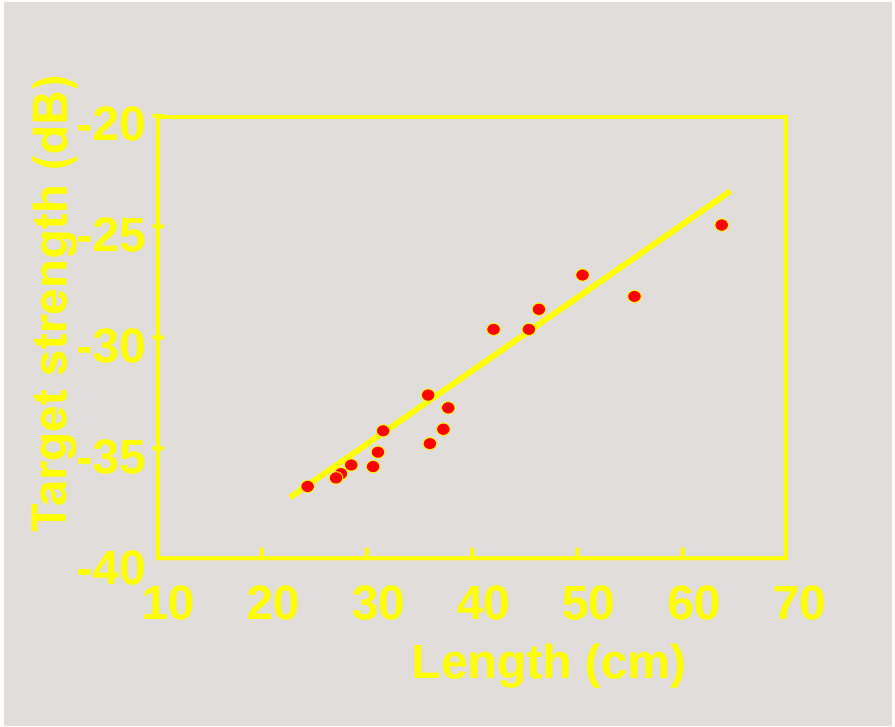
Horizontal sonar

Low Freq. side scan sonar

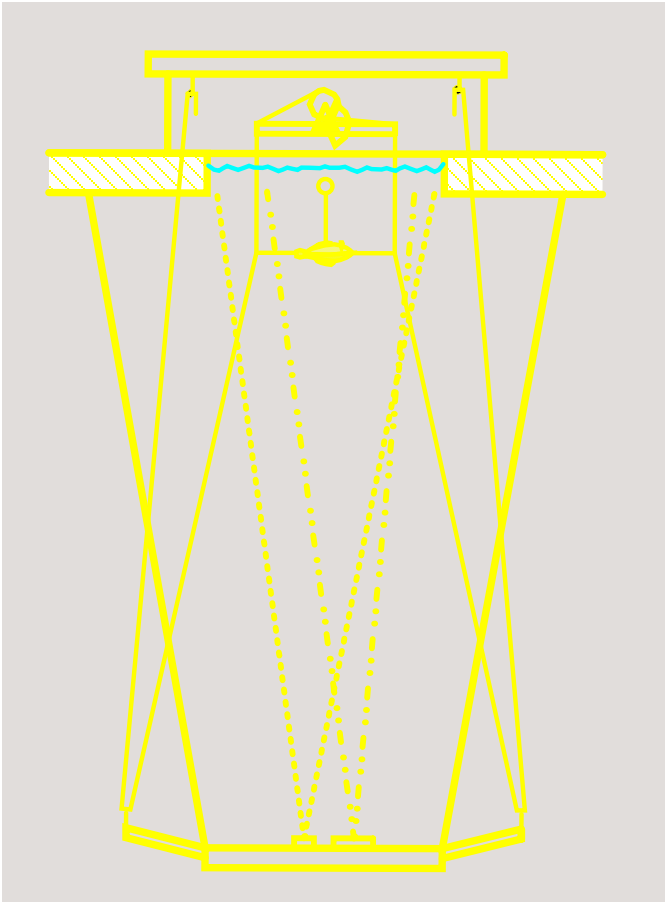


Acoustic Biology

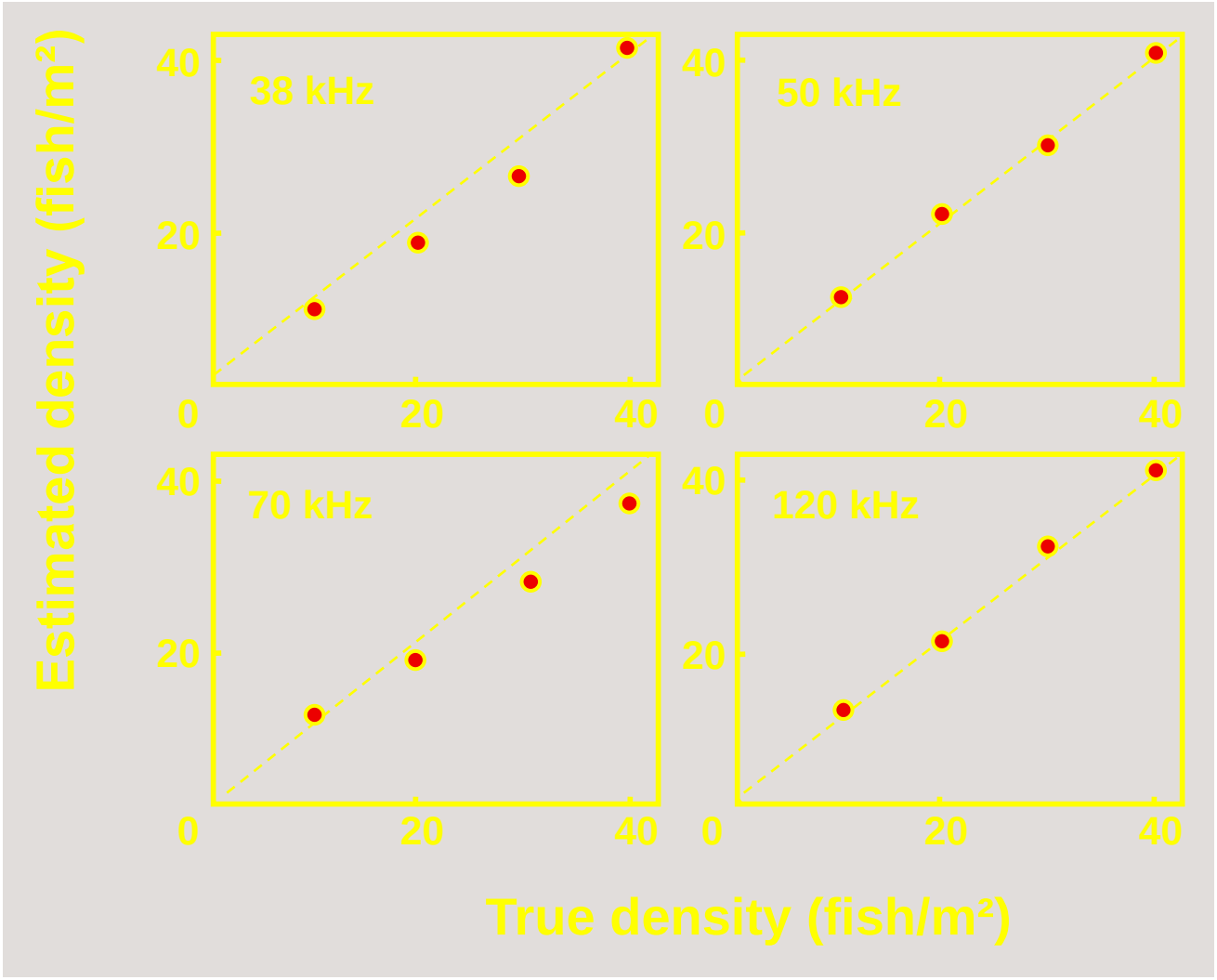
Love (1971): TS $\propto$ fish length



Nakken and Olsen (1977): effect of tilt on TS



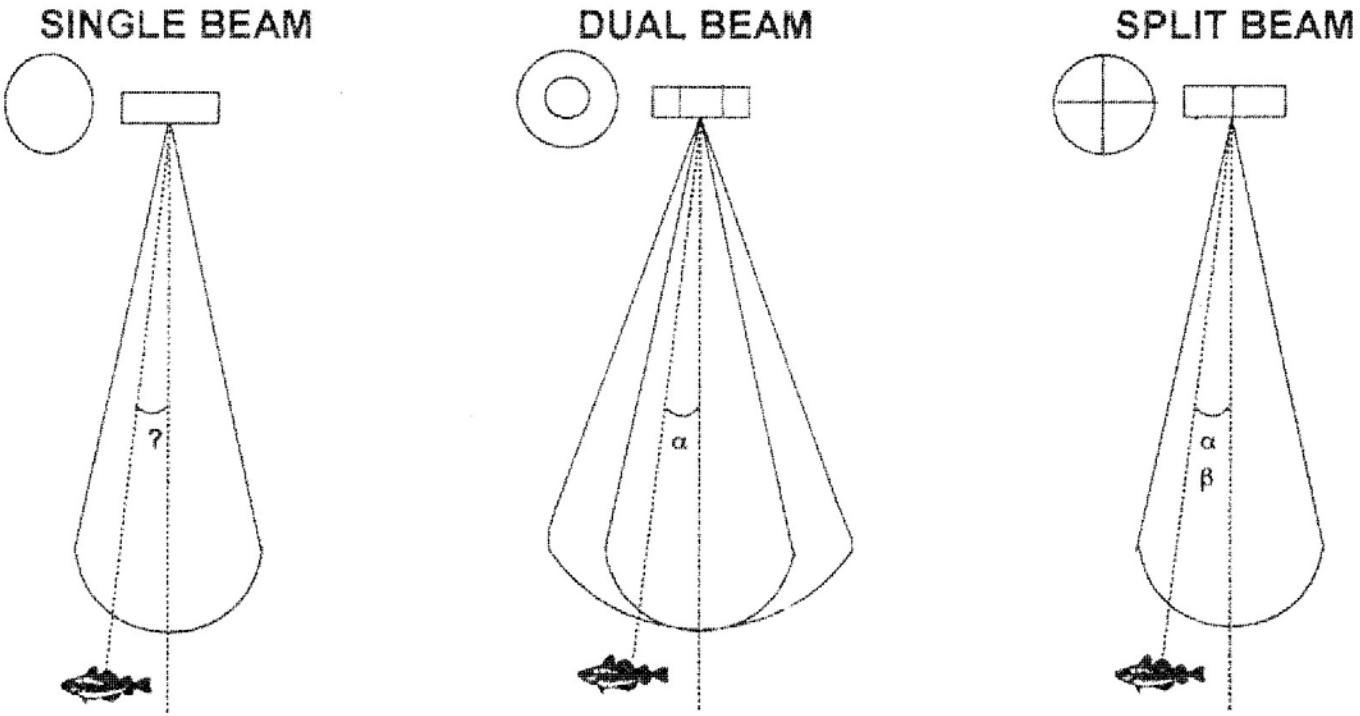
Linearity Principle (Foote 1983)



Scientific Echosounder Evolution

BioSonics 1983

Simrad 1984

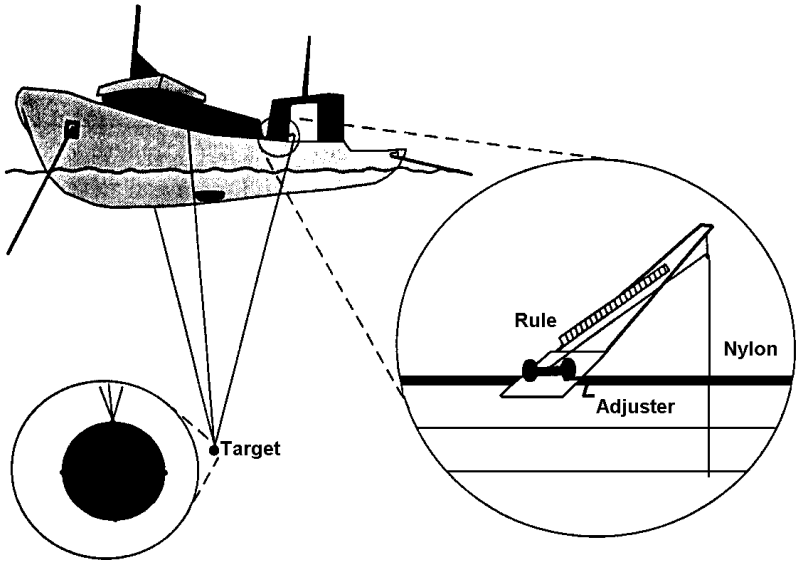


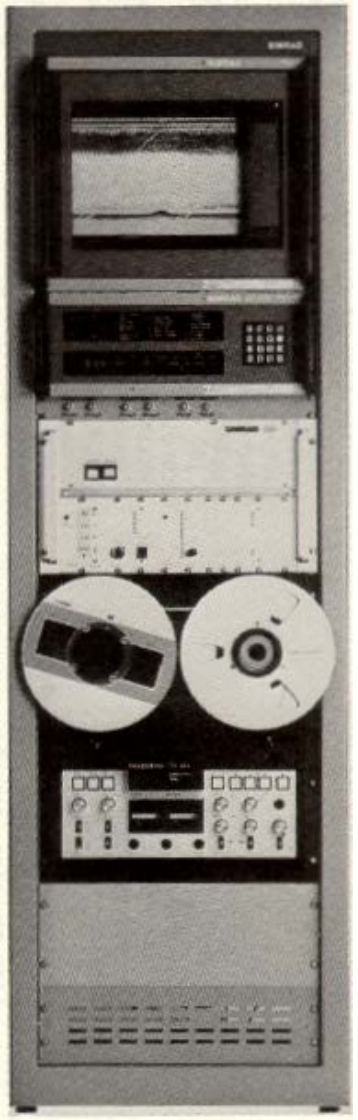
Continued Development

Simrad ES-380, EK-400 (1984)

Foote et al. (1987)

– calibration manual



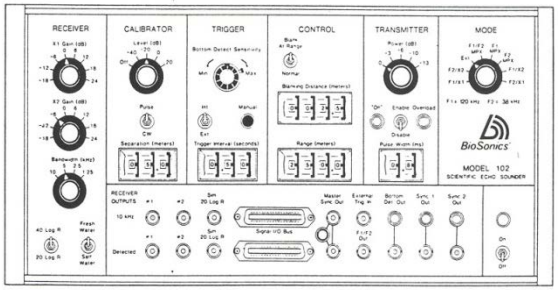


EK-400

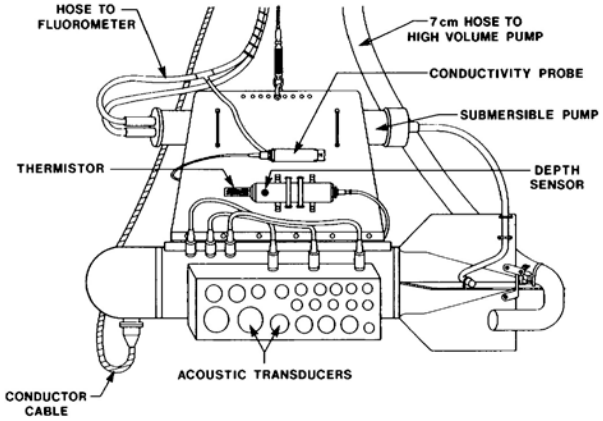
Multi-frequency Systems

Simrad EK-500
(1988)

BioSonics 102 (1989)



Multifrequency Acoustic
Profiling System (MAPS 1995)

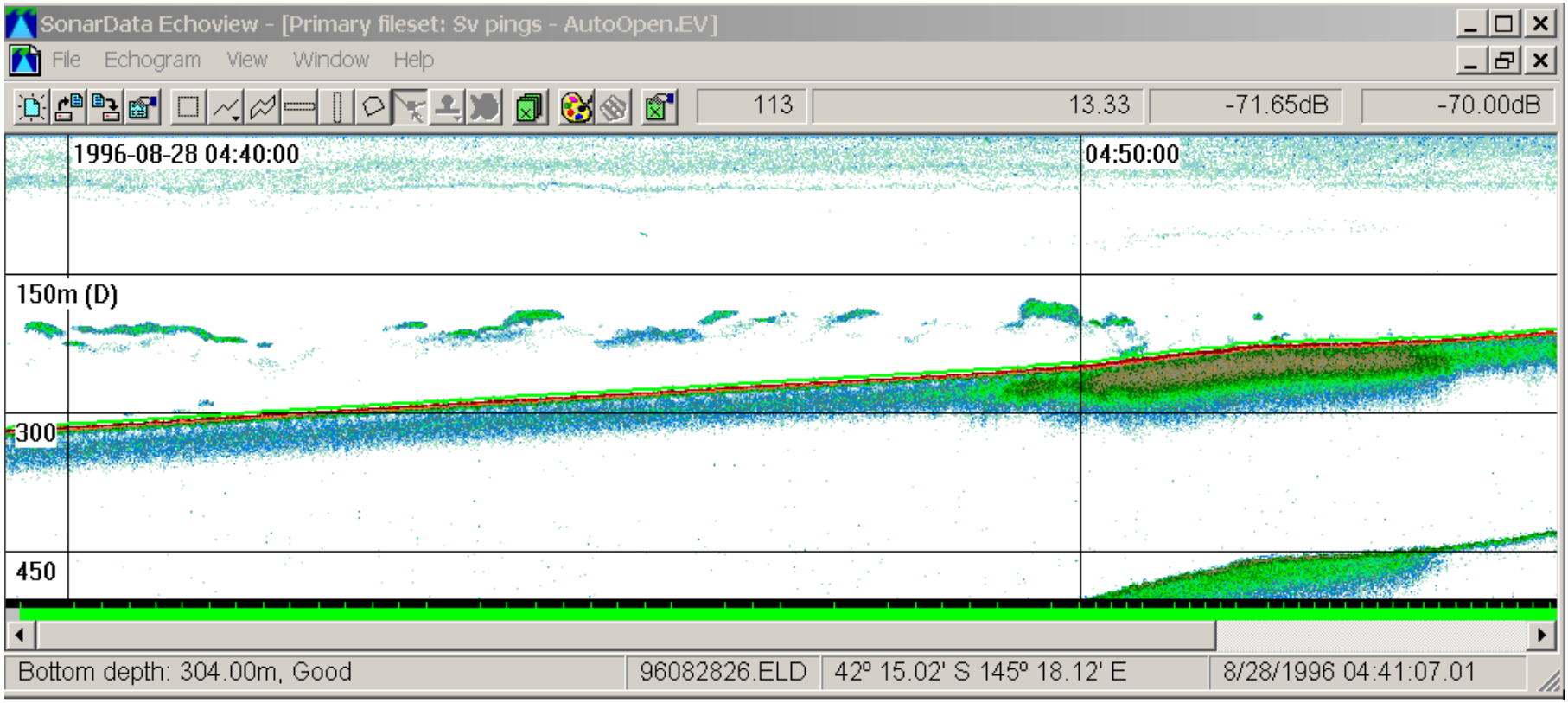


Standardization of Techniques (1990s)

Survey Design

EchoView Software (1995)

TS methods (Ona 1999)

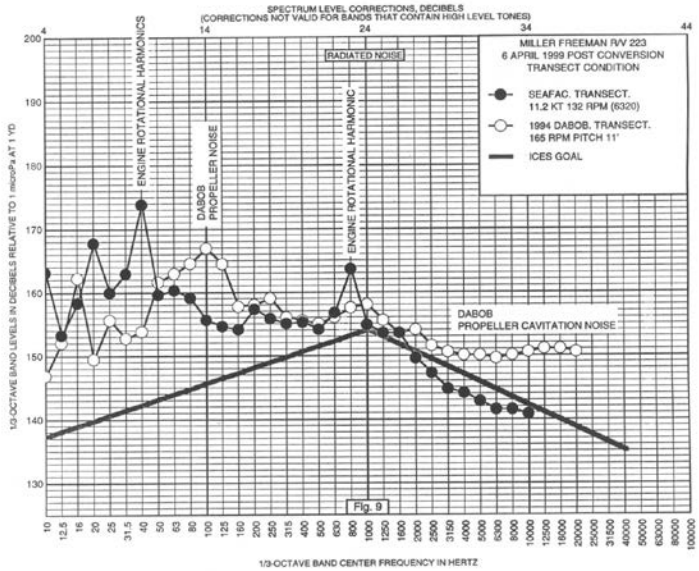


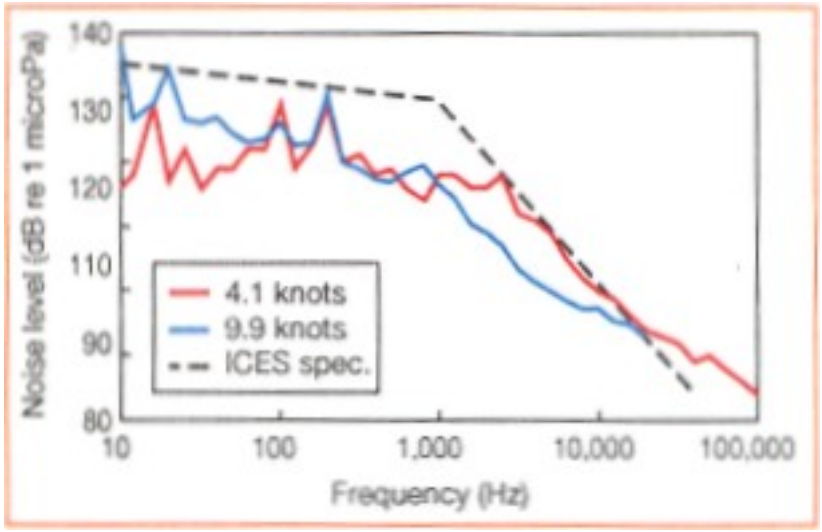
Vessel Noise Standard

Mitson (1995): ICES 209

Miller Freeman

Scotia





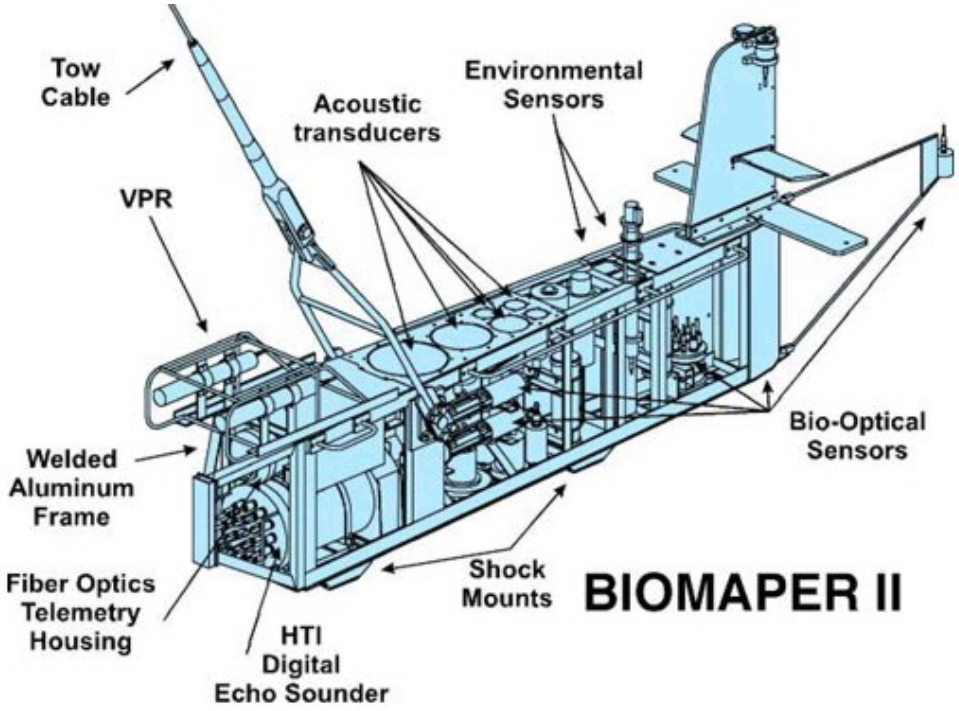
Atlantic herring at 20 m

Technological Advances

‘Digital’ transducer: Biosonics DT series 1994

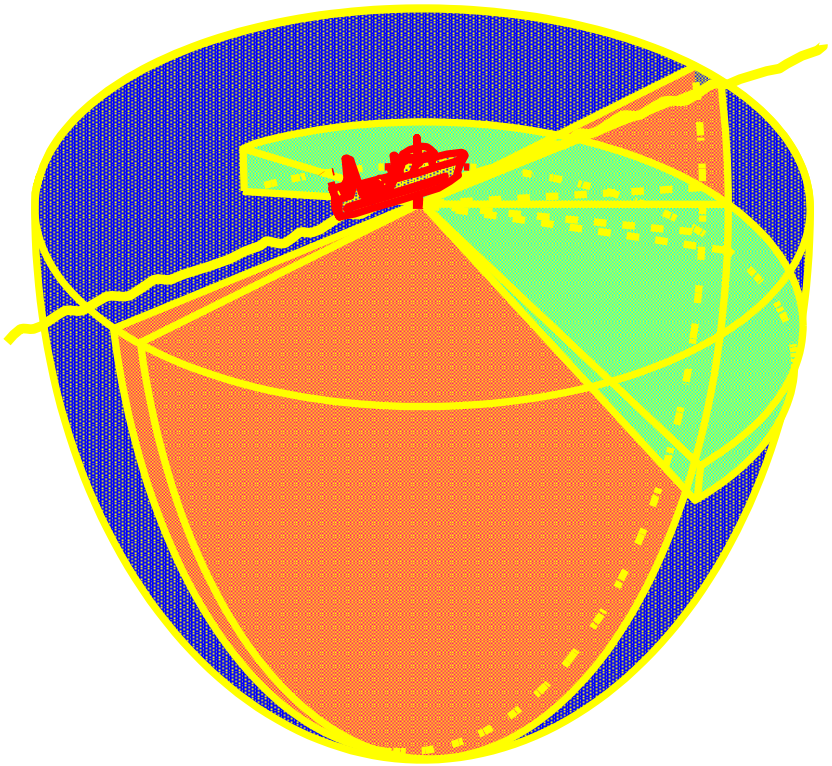
Environmental sensor integration: Biomapper II

Alternate platforms: AUV

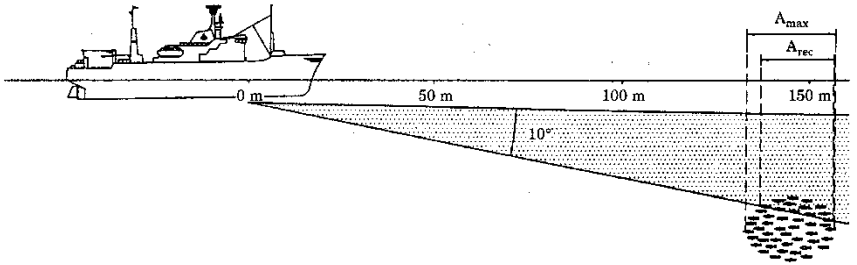


School Volumes

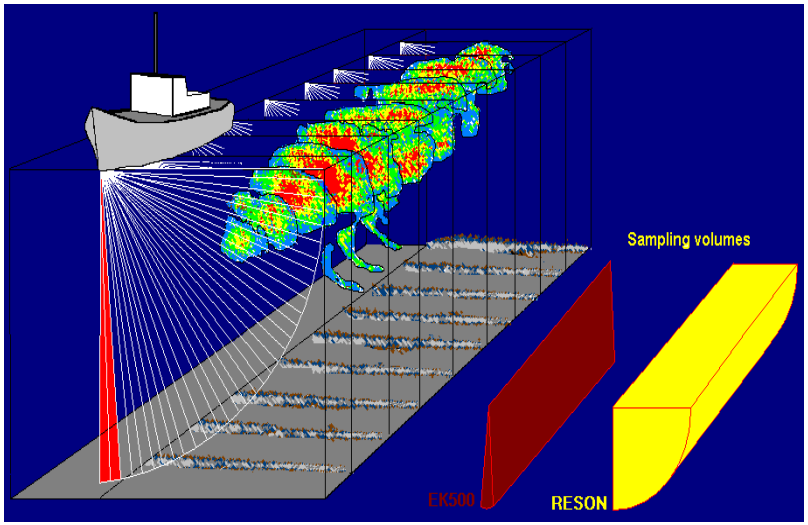
Multibeam Sonar Applications



Horizontal: Misund et al. 1995



Vertical: Gerlotto et al. 1999



Acoustic Visualizations

Multibeam Sonar Applications

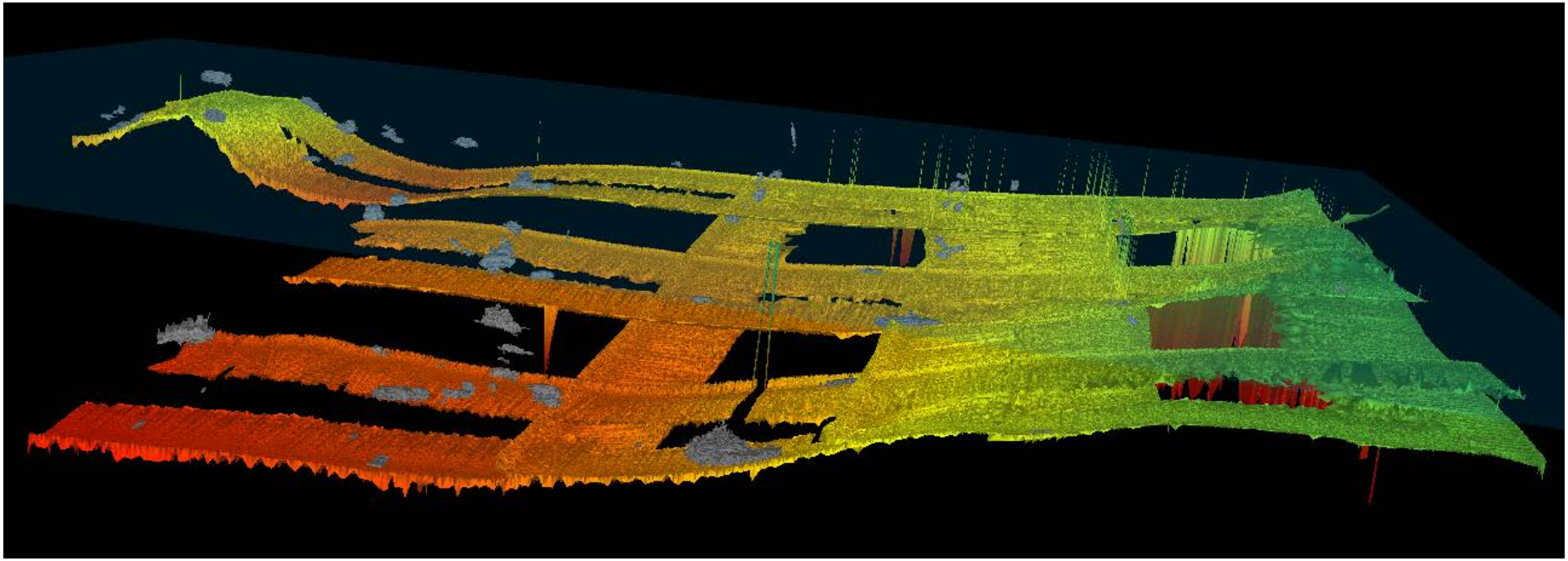
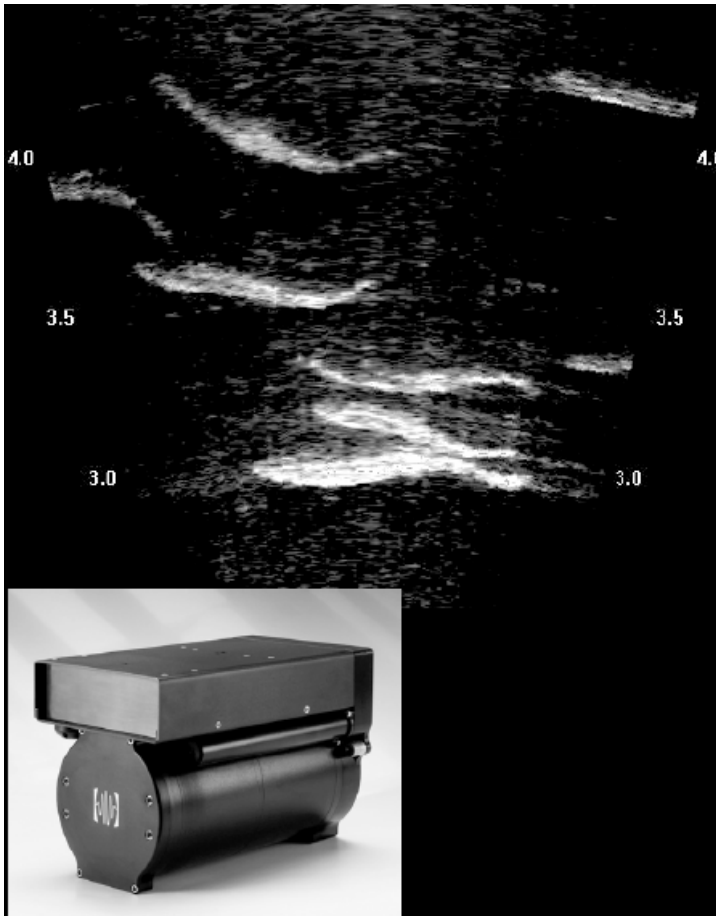


image M. Wilson

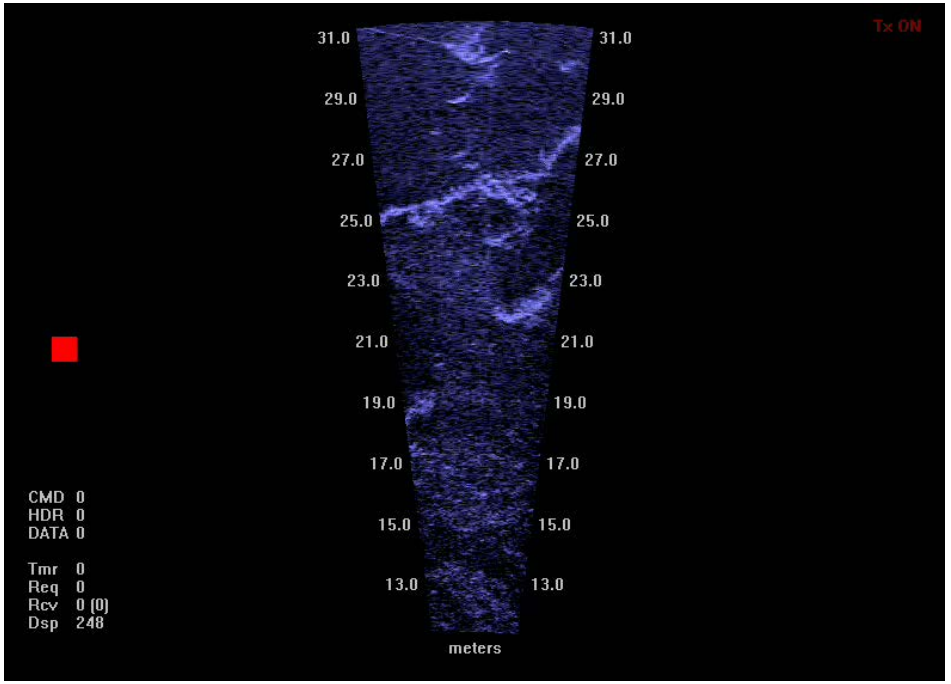
Herring Schools, Salmon Bank, San Juan Island, WA

Imaging Sonars: Acoustic Cameras

Dual Frequency Identification Sonar: acoustic imaging sonar



- 900 kHz - 1.8 MHz
- 96 beams
- 0.3^{o} horizontal x 11^{o} vertical



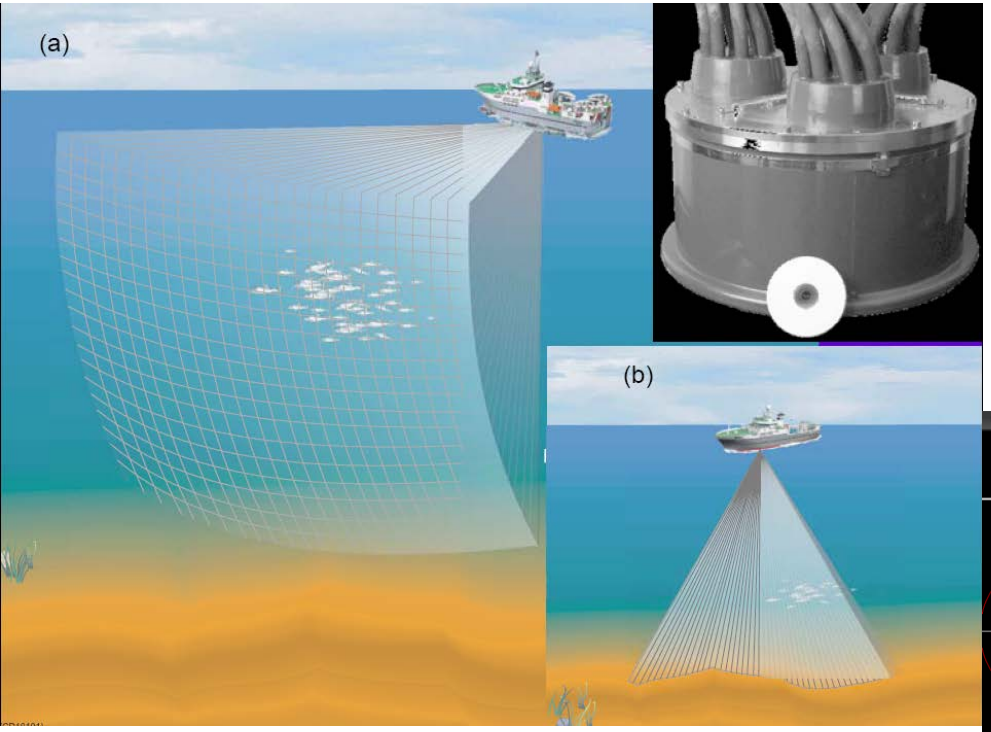
Next Generations (2000s - 2010s)

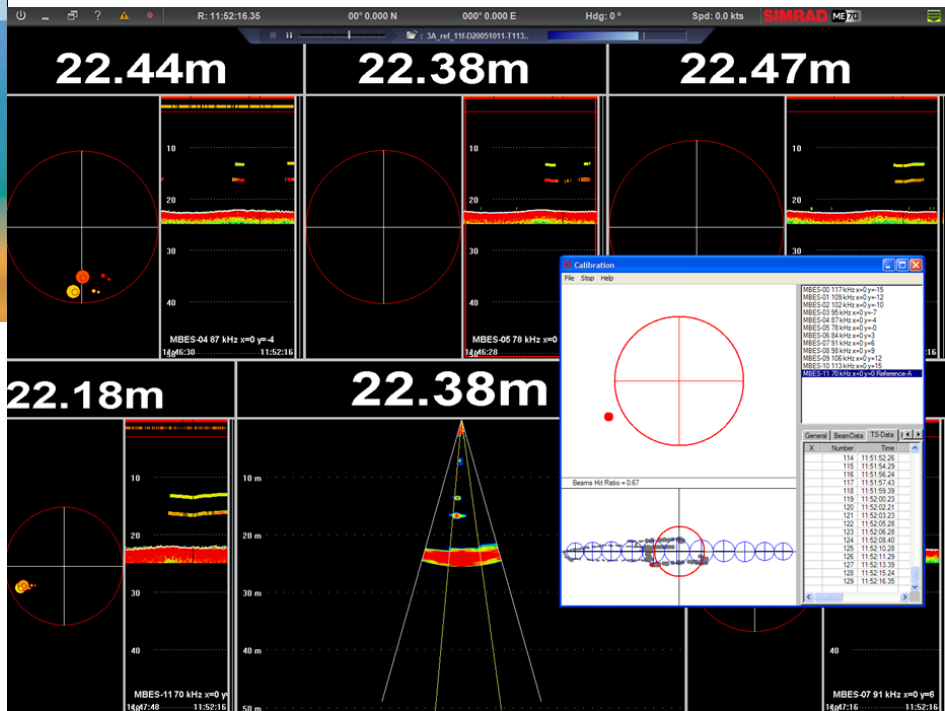
Simrad EK-60 (2001)

Cabled Probes (IMR 2009)

ME/MS 70

broadband, multibeam echosounder/sonar

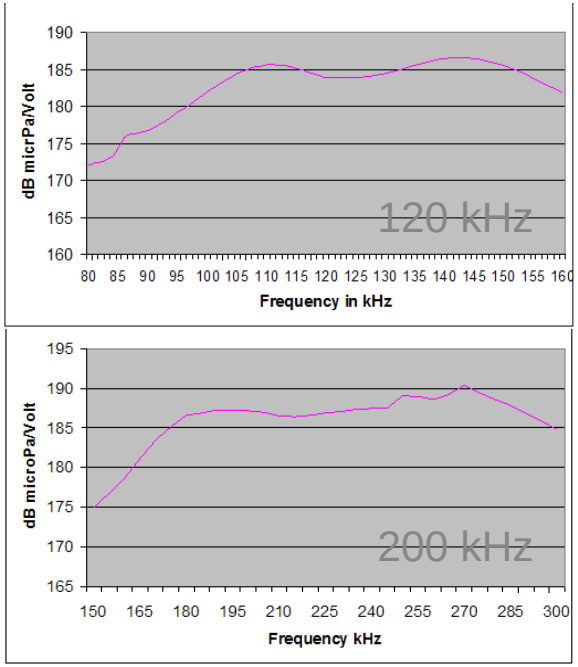


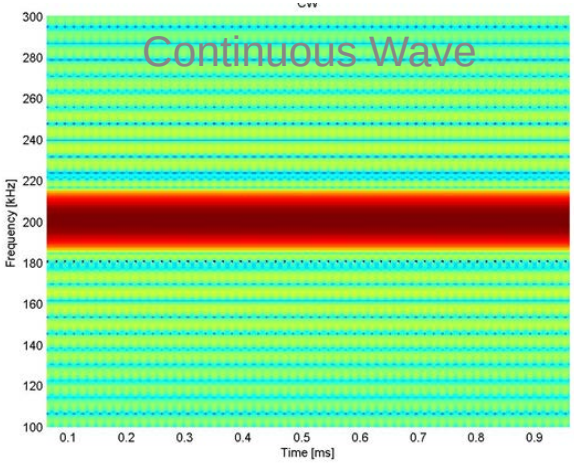


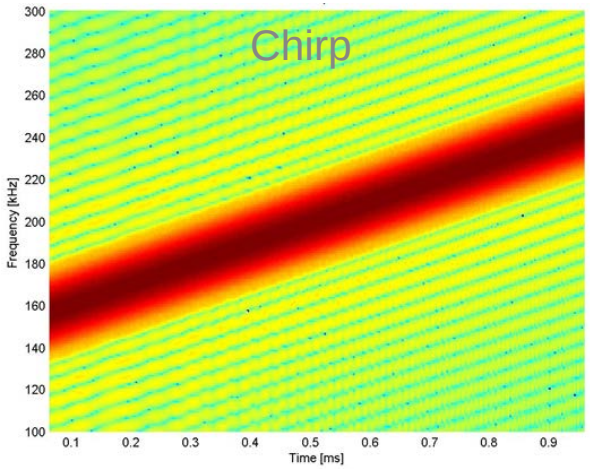
configurable beams, frequencies

Broadband Revisited

Transducers and transceiver - discrete and broadband data







Konsberg EK-80

* HTI has offered matched filters since 1992

Conclusions

Technological advances (hardware and software) continue

Diverse set of hardware and analytic approaches

Integration of hardware on common platforms

Dynamic set of applications with fundamental goals