Introduction to Singlebeam and Multibeam

LT Olivia Hauser

Field Operations Officer, NOAA Ship Rainier

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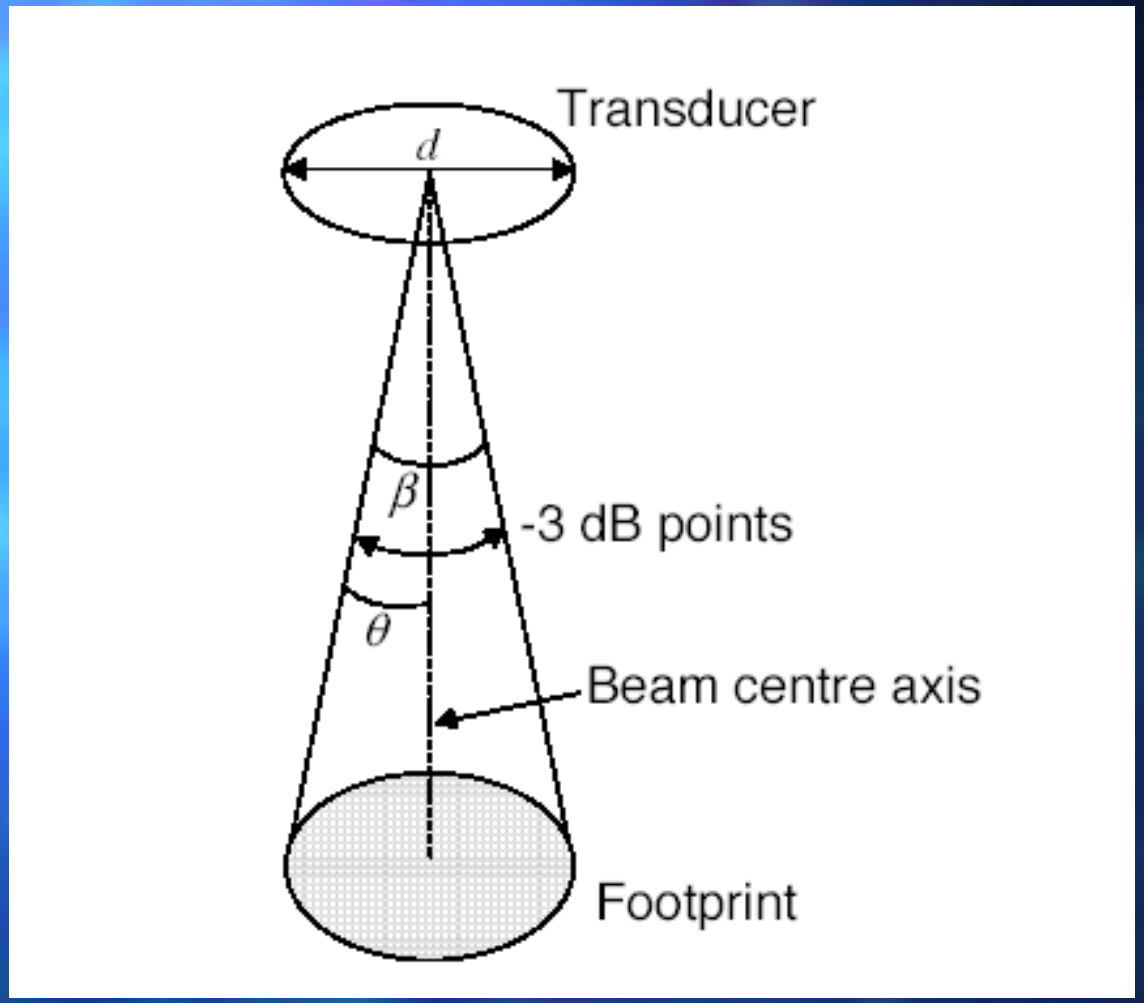
Learning Objectives

- Singlebeam overview
- First Return and Beam Footprint
- Multibeam overview
- Beam Forming
- Multibeam Transducer Anatomy
- Vessel Attitude and Motion
- Offsets and biases
- Multibeams and Singlebeams on NOAA fisheries and Oceanography vessels

What is single beam sonar?

- A transducer (sound producer) that puts sound in the water and listens for a return
- Usually at a specific frequency with a single beam
- Sound spreads as it goes into the water


Transducer
d
β
-3 dB points
θ
Beam centre axis
Footprint

Purple = Low Frequency

Pink= High Frequency

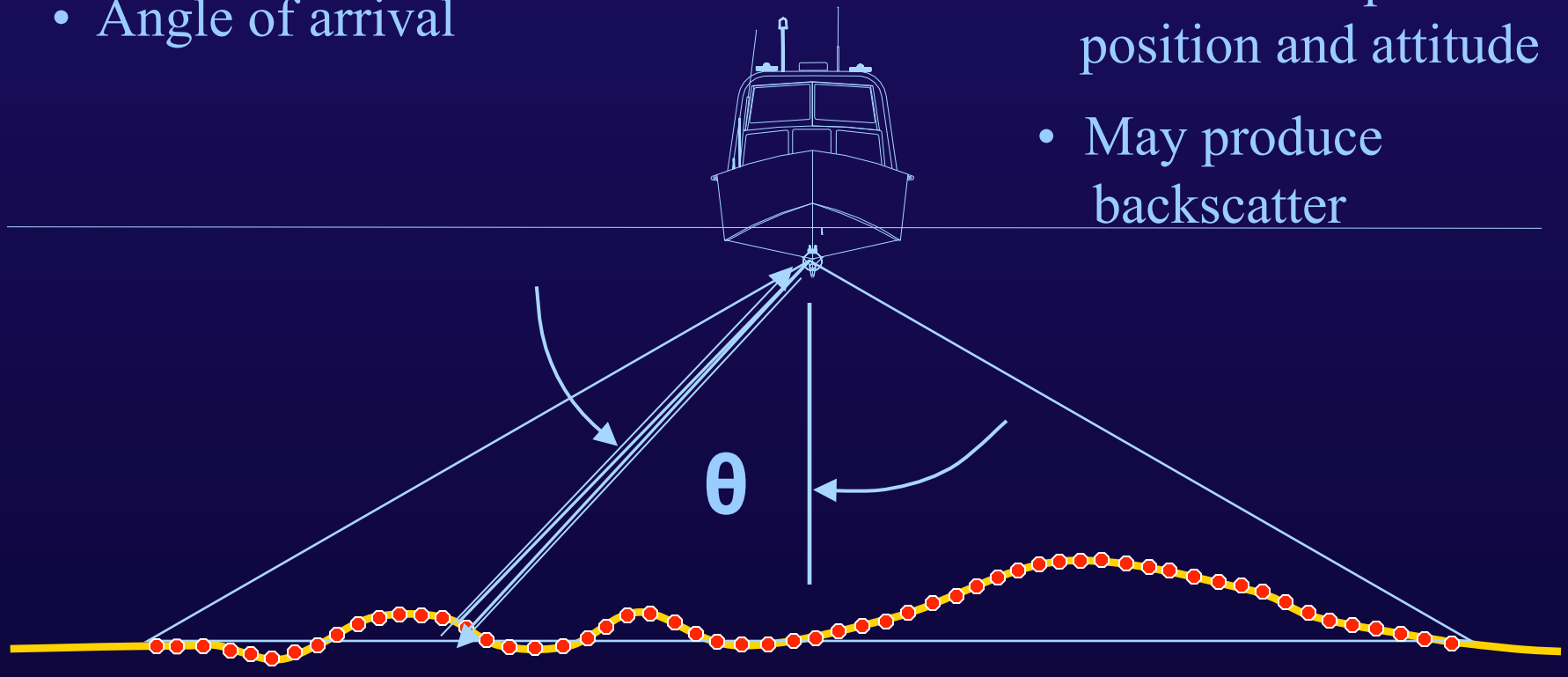
Concept of First Return

The depth measured by the pink will not be the same as the purple. Why?

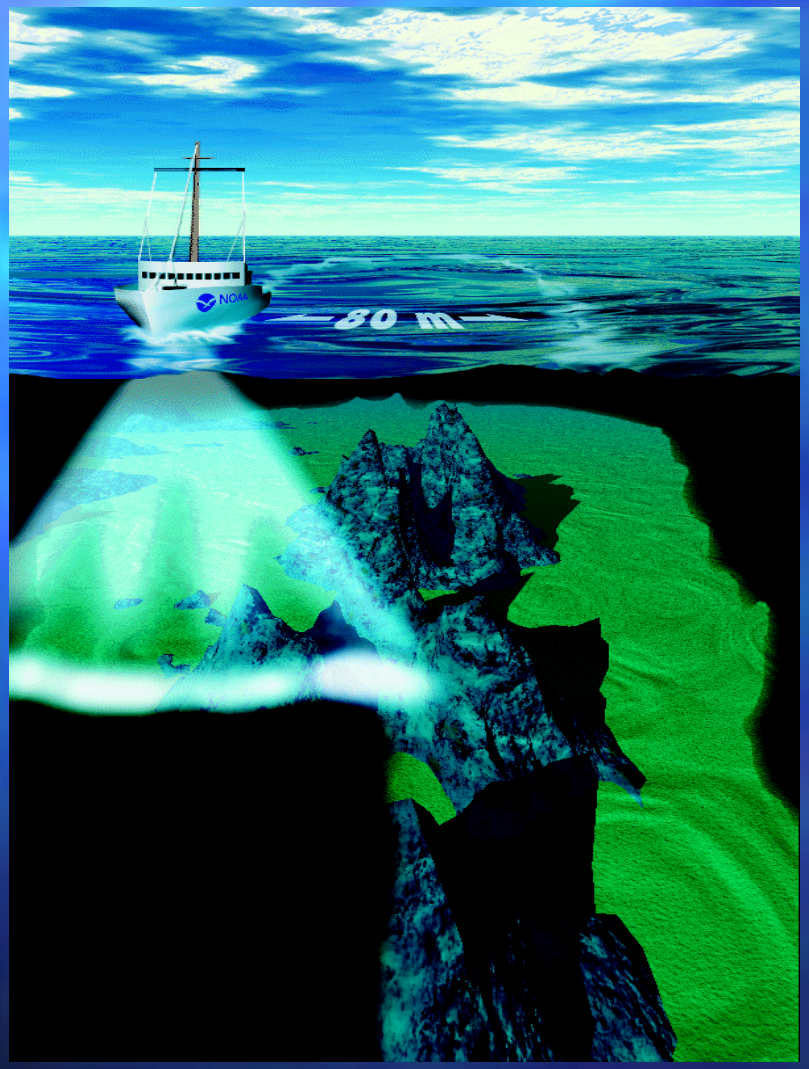
What is a multibeam sonar?

- Acoustic Device
- Two-way travel time
- Angle of arrival

- Swath of discrete sounding
- Must be couple with position and attitude
- May produce backscatter

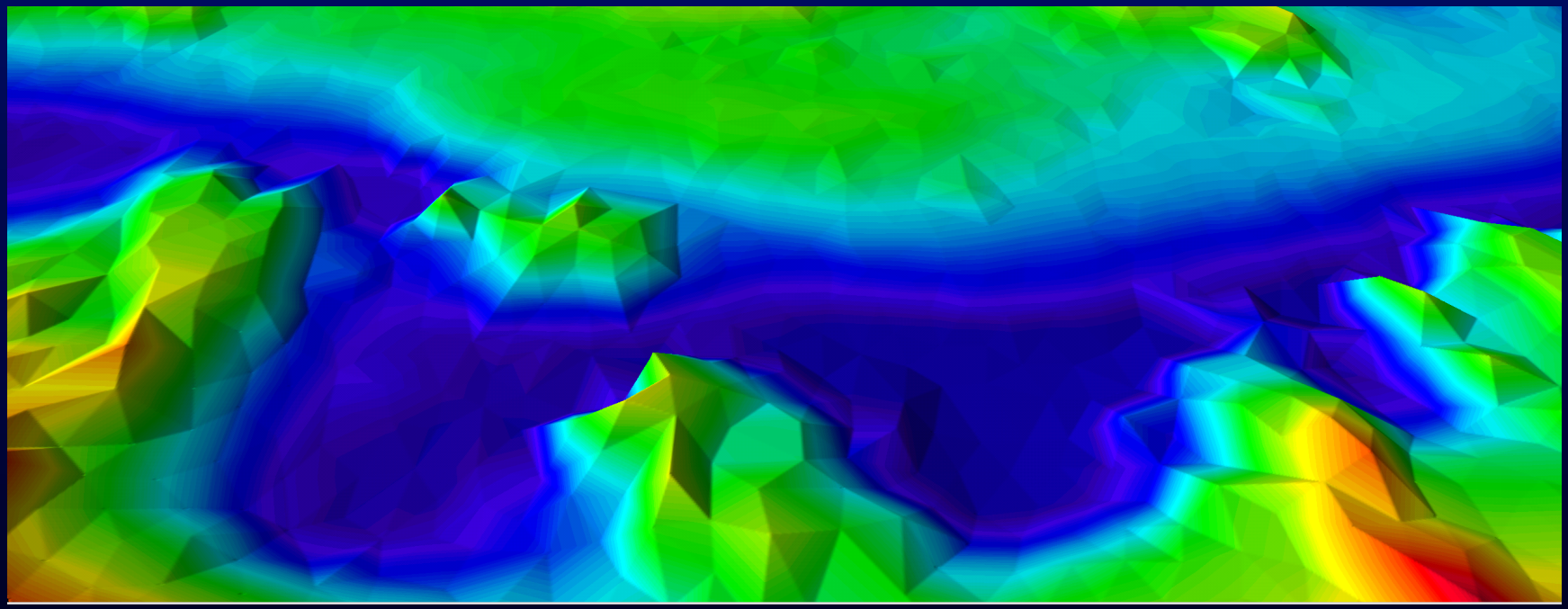


Benefits of Multibeam Sonar



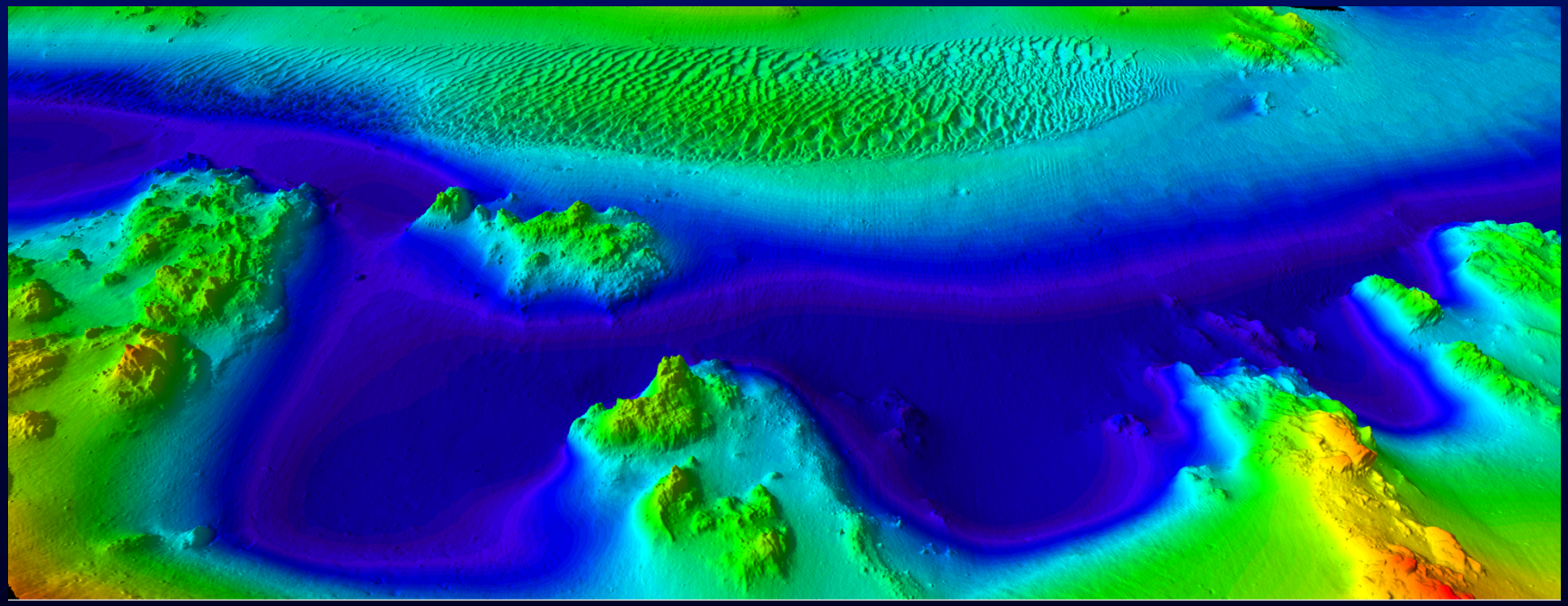
- Full bottom ensonification
- Greater confidence
- Higher resolution = easier to model = easier to interpret
- Highly sought after data
- Capable of producing "calibrated" backscatter

Sounding Density



Single Beam Density Selected Soundings

Sounding Density



Multibeam - Navigation Surface Depth Model

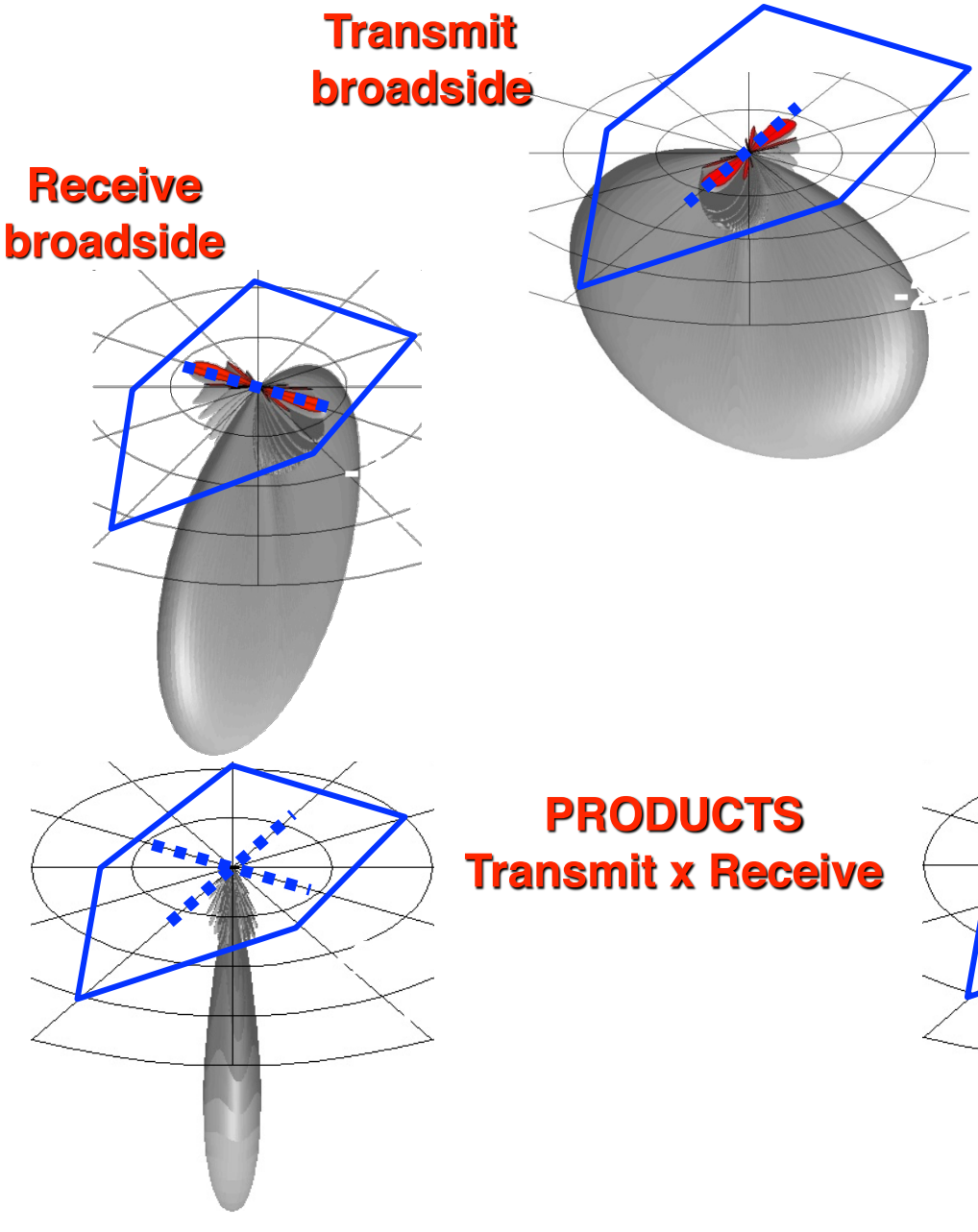
So, how does this work?

Check out the point source demo!

http://www.falstad.com/ripple/

Transmit broadside

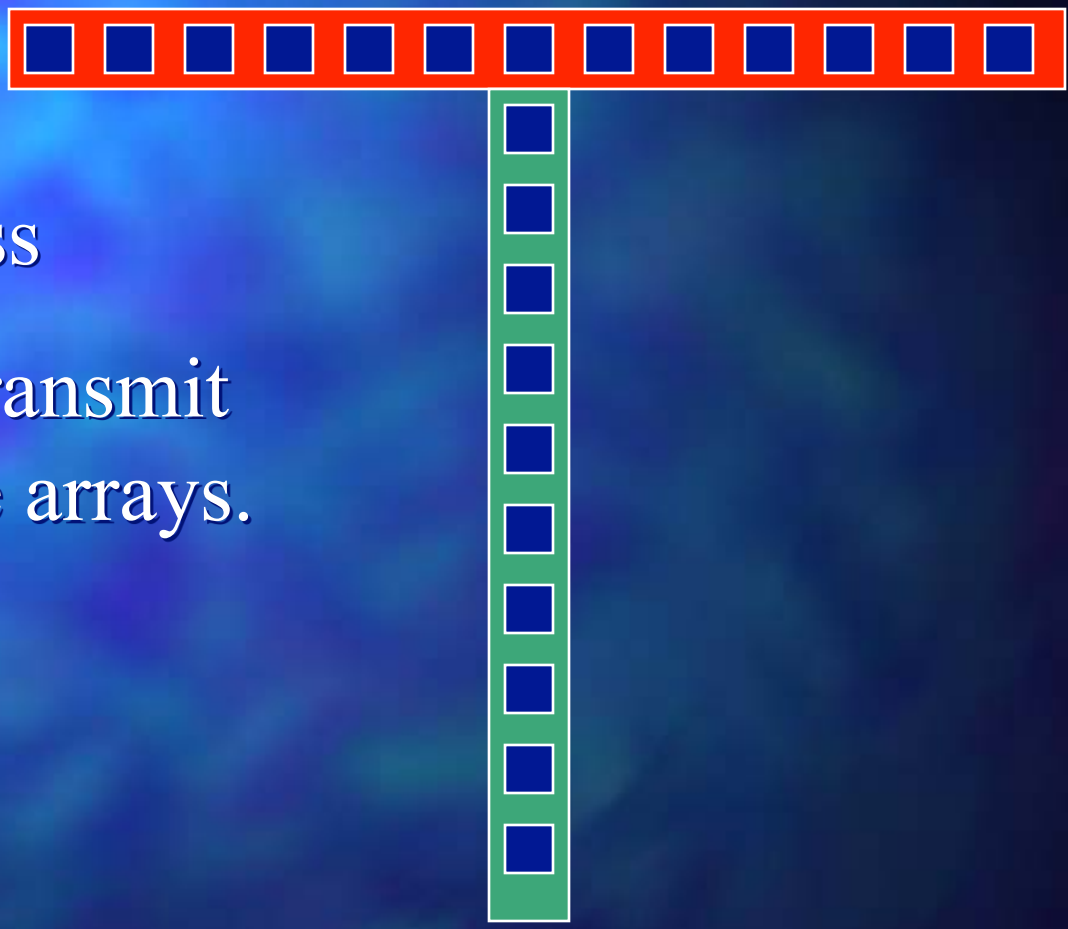
Receive broadside



Receive 30º

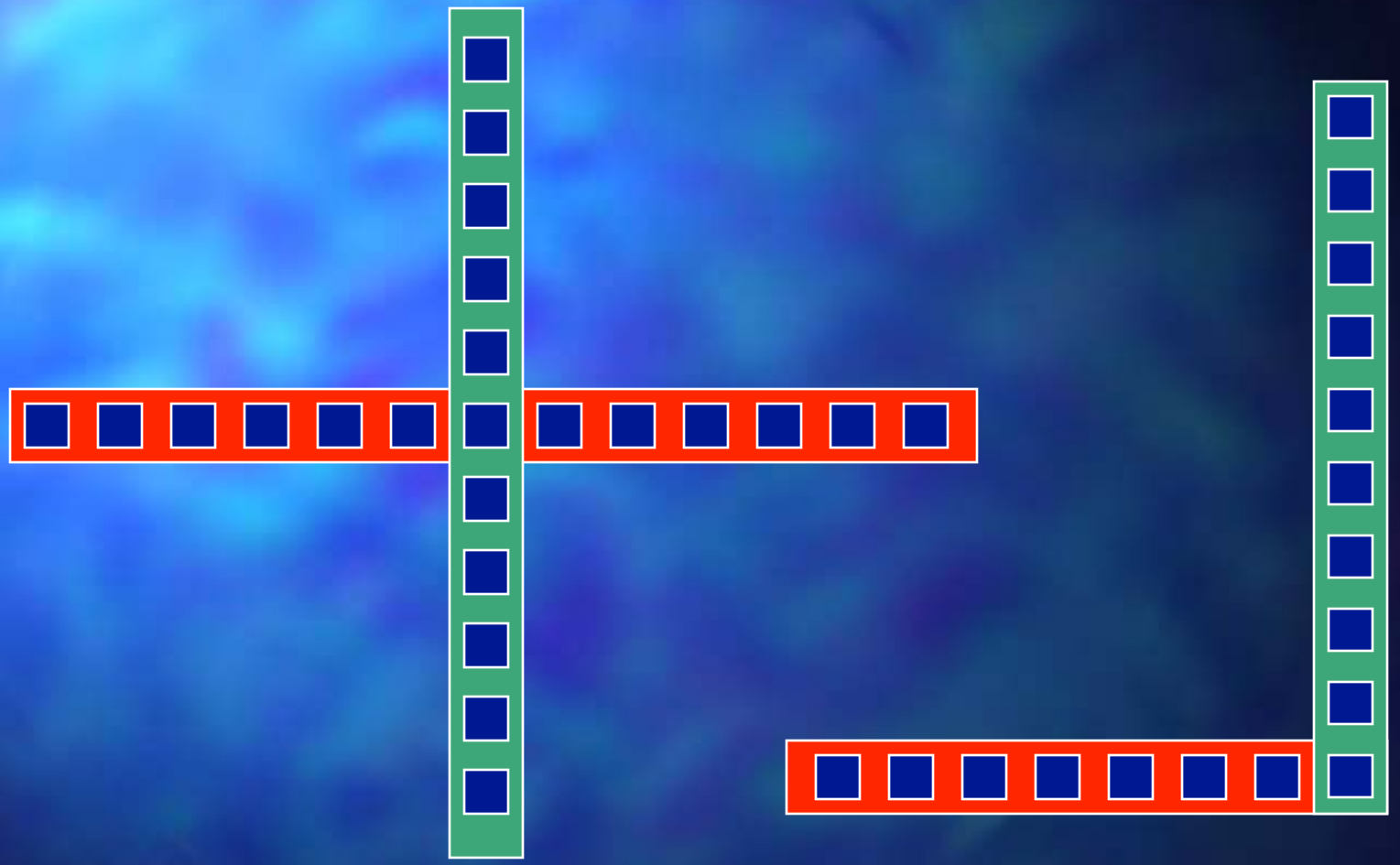
PRODUCTS
Transmit x Receive

Multibeam Anatomy



- Mills Cross
- Separate transmit and receive arrays.

Multibeam Anatomy



Sonar Arrays

- An array is nothing more than multiple elements arranged in some geometric pattern.
- This arrangement is designed for the specific use of the array.
- A Uniform Line Array is a simple but effective array and is found in many current systems.

Beam Pattern

- Product of transmit and receive
- Simplest methods of beam forming use Fast Fourier Transform (FFT) or "delay-and-sum"
- Defines the spatial resolution of a sonar.
- Intersection of transmit, receive and seafloor is the "foot print" of the beam.

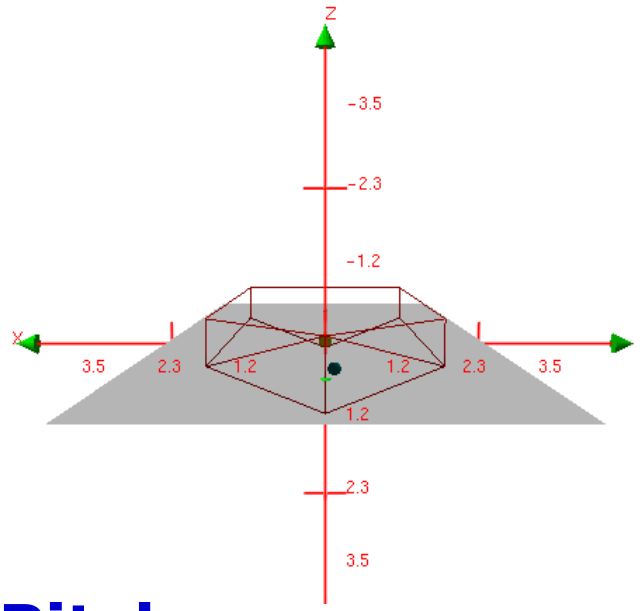
Beam Patterns

- Controlling dimensions of beam patterns:
  - Array Dimensions (i.e. length or diameter)
  - Acoustic Wavelength
  - Element Spacing
  - Element Shading
- Beam pattern goals:
  - Focused main lobe (narrower is better)
  - Reduced side lobes (fewer and smaller is better)
  - Finding the happy medium

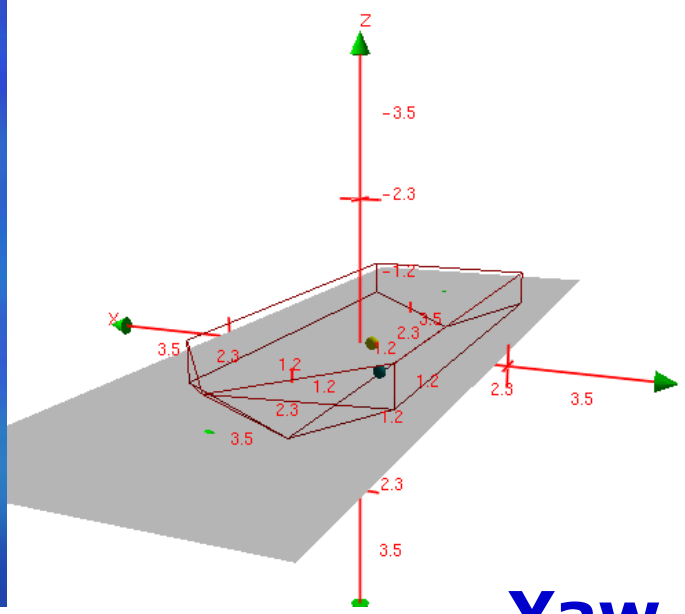
Vessel Attitude

- The boat/ship is never still
- When measuring depth, or position of a return, you need to compensate for vessel movement (attitude)
- Different types of equipment that measure vessel – POS/MV is most commonly used in NOAA
- What are the four major vessel movements?

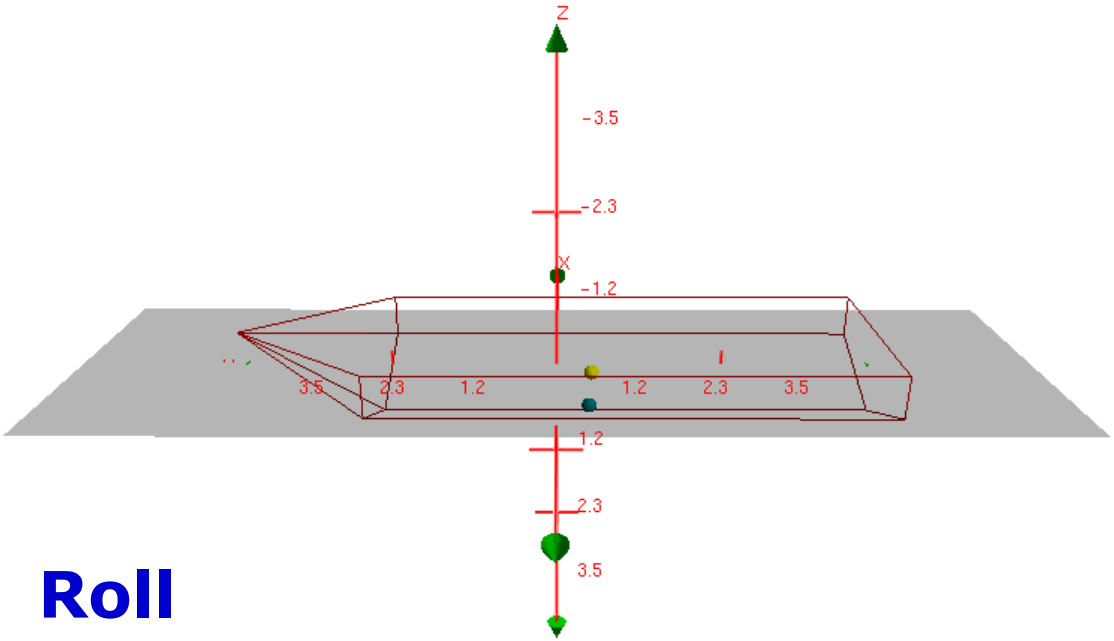
Vessel Attitude



Pitch



Yaw



Roll

Multibeam Offsets & Errors

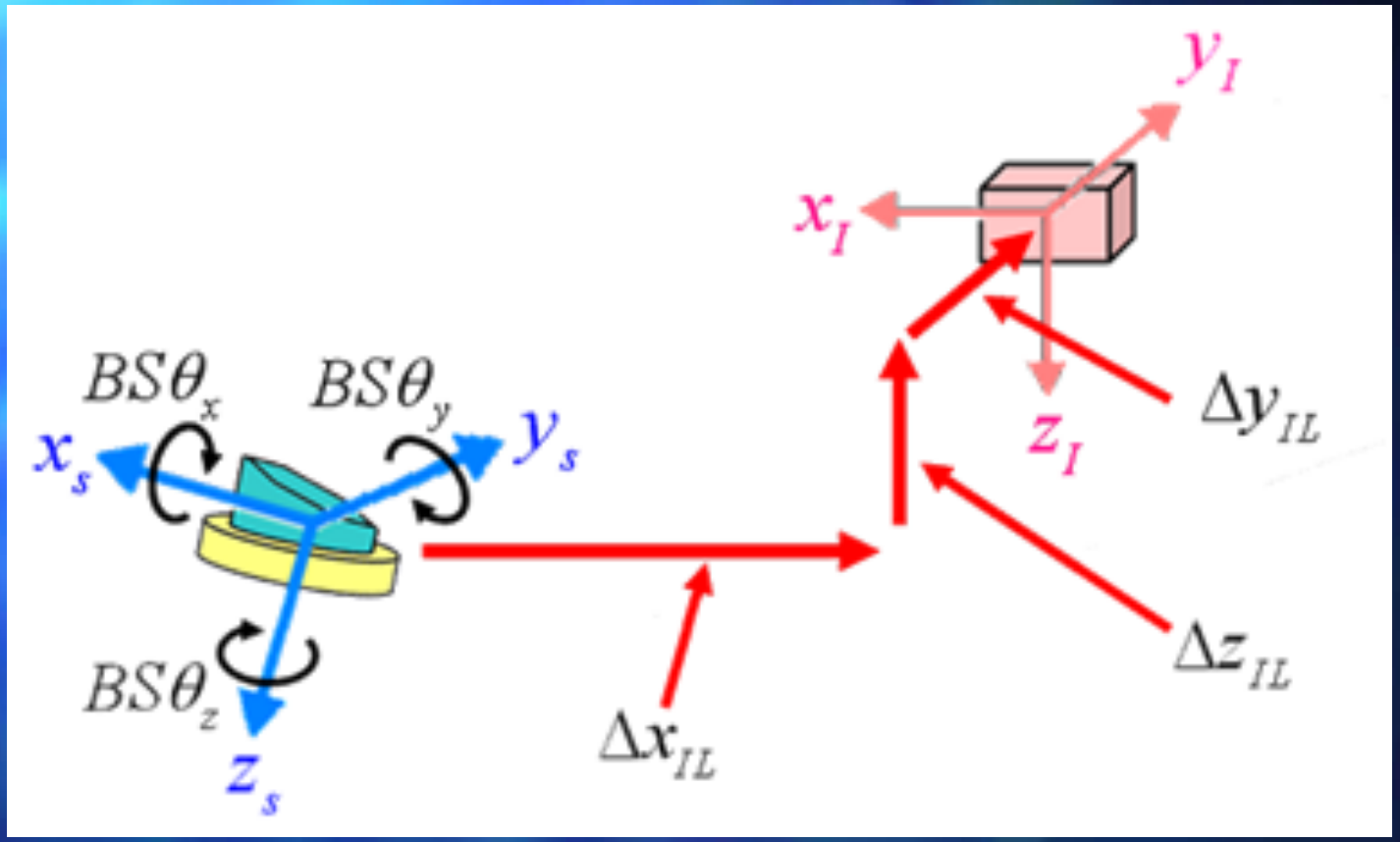
Multibeams are much more sensitive than singlebeams to measurement offsets and errors.

And, we are much more likely to notice.

Offsets and Biases

- Offsets:
  - Ship survey
  - Transducer to IMU
  - IMU to GPS Antenna
  - Distance between antenna
  - Distance between transducers
- Biases:
  - How is the multibeam installed with respect to the vessel reference frame

Offsets and biases

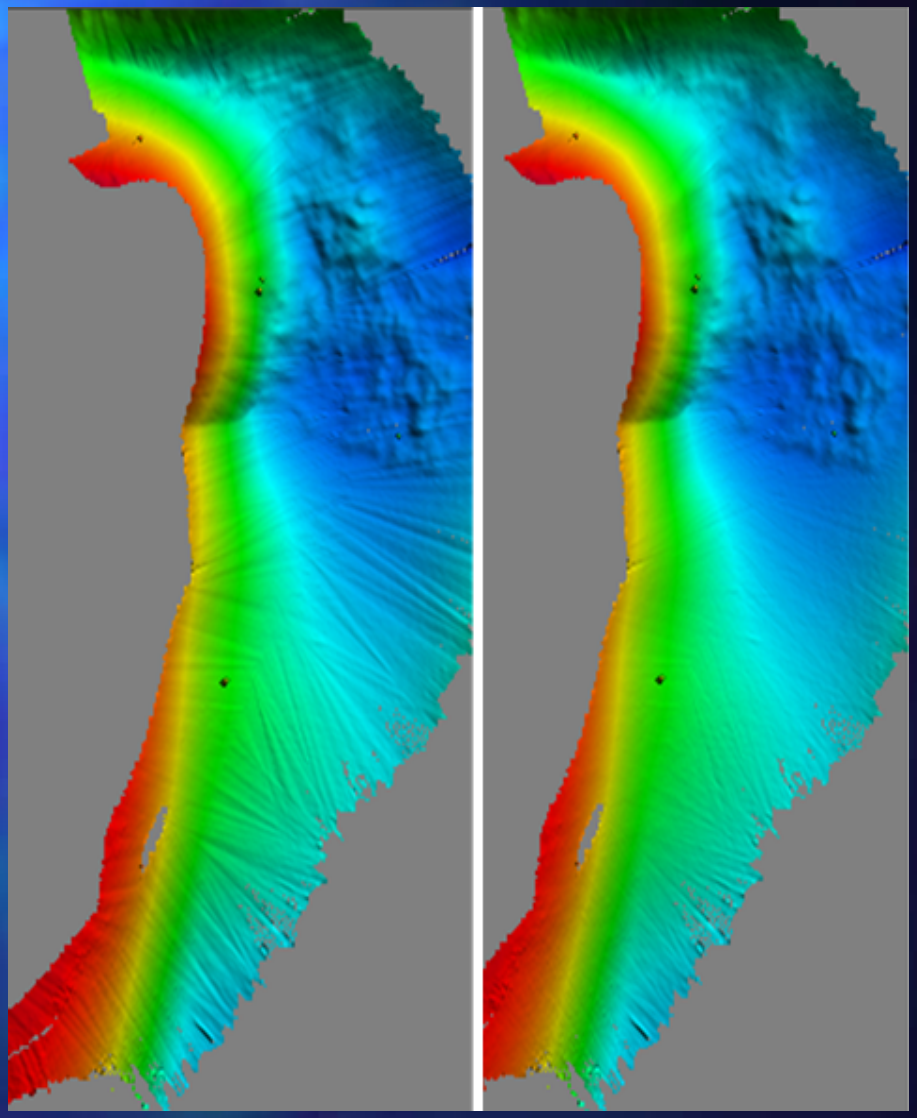


Multibeam Alignment Calibration

Patch Test

(Very important for data quality)

Multibeam Alignment Calibration



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Singlebeams

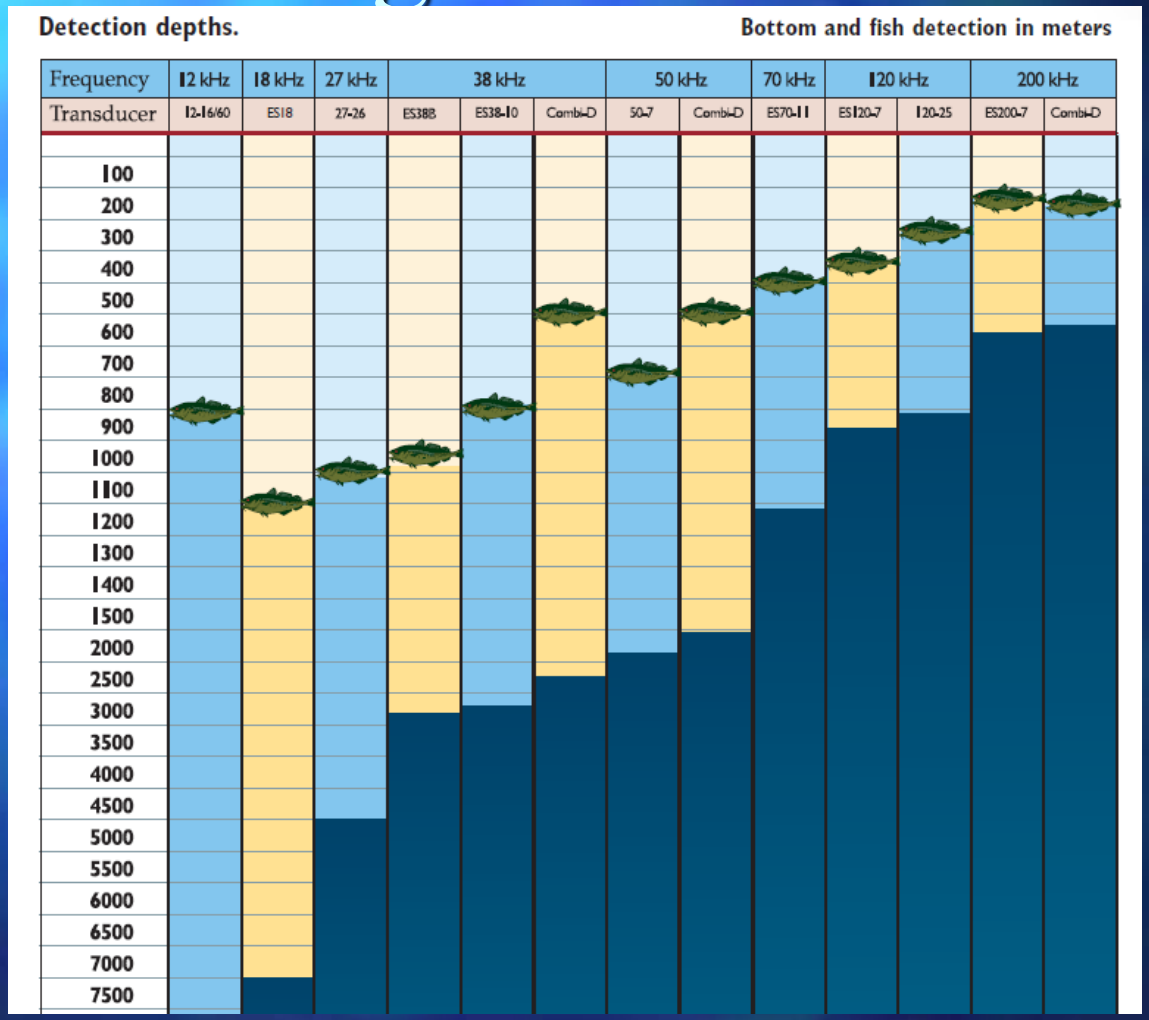
ES 60

EK 60

Singlebeam : ES 60

- Simrad manufactured
- Choose up to 4 frequencies selection range 12 to 200kHz
- Up to 4 frequencies in one display
- Adjustable beam direction
- Beam opening 2 to 20 degrees (adjustable)
- Motion compensated
- Fisheries specific

Singlebeam : ES 60



Singlebeam : EK 60

- Simrad manufactured
- Choose up to from frequencies selection range 18, 38, 70, 120, 200 and 333 kHz
- 7 degree beam angle (Except for 18kHz)
- Observe horizontal position of fish in the sound beam
- Myriad of post processing abilities
  - Biomass
  - Fish behavior
  - Different fish sizes at the same time

Multibeams

ME 70

SM 20

EM300

EM3002

Reson 7125

Multibeam : ME 70

- Simrad manufactured
- Frequency range 70 to 120 kHz
- 3 to 45 beams
- Maximum 140 degree swath
- Adjustable beam direction
- Beam opening 2 to 20 degrees (adjustable)
- Motion compensated
- Fisheries specific

Multibeam : SM 20

- Simrad manufactured
- Consists of a SM2000 multibeam and SM20 processing software
- 200 kHz
- 128 Beams
- Maximum 180 degree swath
- Beam size 20 x 2 degrees
- Fisheries specific

Multibeam : EM300

- Simrad manufactured
- Deeper water system
- Frequency 30 kHz
- 135 Beams
- Maximum 150 degree swath
- Beam size 1x1, 1x2, 2x2 or 2x4
- Depths to 5000 meters
- More bathy than fisheries

Multibeam : EM3002

- Simrad manufactured
- Shallower system
- Frequency 300 kHz
- 135 Beams
- Maximum 150 degree swath
- Beam size 1x1, 1x2, 2x2 or 2x4
- Depths to 1-200 meters
- More bathy than fisheries

Multibeam : Reson 7125

- Reson manufactured
- Frequency 200 kHz and 400 kHz
- 256 and 512 Beams
- Maximum 140 degree swath
- Beam size .5 x.5 degrees
- Depths to 1-200 meters
- More bathy than fisheries
- Great backscatter

Questions ?

Sound Velocity

- Sound Velocity is second-largest source of error for nearshore surveys
- Time and effort required for additional casts is ALWAYS less than re-surveying an area

- Payoffs in uncertainty and quality of final surface
- YOU control how accurate your data can be