Pro's Corner

Deciphering Sonar Charts.

By Luke Morris

Introduction

This tutorial or guide is to provide rudimentary education into sonar principles and applications, based on accepted electronic theory and principles, to explain how, what, and why your sounder displays sonar echo data.

It would not be possible to illustrate every possible example of sonar chart data you may see. However with a basic understanding of how sounders and transducers operate, and how that information is depicted on the screen, you should be able to quickly and accurately interpret all of the myriad of different chart examples you may encounter.

This tutorial is written from a layman's perspective and is not intended to be the definitive or complete source for this nature of information. Nothing can replace knowledge of local waters or time spent on the water over known targets to test or interpret sonar readings. And the more familiar you become with the functions and features of your specific sounder model the better able to read the display you will become.

Sonar Principles

Echo location

In the simplest terms, an electrical impulse from a transmitter is converted into a sound wave by the transducer and sent into the water. When this wave strikes an object, it rebounds or echoes. This echo strikes the transducer, which converts it back into an electric signal, which is amplified by the receiver, processed into pixel information, and sent to the display. Since the speed of sound in water is constant (approximately 4800 feet per second), the time lapse between the transmitted signal and the received echo can be measured and the distance or **RANGE** to the object determined. This process repeats itself many times per second.

The sonar unit sends and receives signals, then "prints" the echo on the display. Since this happens many times per second, a continuous line is drawn across the display, showing the contour of the bottom. In addition, echoes returned from any object in the water between the surface and bottom is also displayed. By knowing the speed of sound through water (4800 feet per second) and the time it takes for the echo to be received, the unit can show the depth of the water (range to the bottom below the transducer) and **range** of any suspended targets in the water.

Propagation

A sound wave is unlike a light wave or radio wave. Sound waves are considered a mechanical wave which is best described as one molecule of water which pushes against another, which pushes against another, which pushes against another, which pushes against another, and so on. Like a rock dropped in a pond the waves goes outward until it strikes and object and returns an “echo” or travels far enough to be disbursed. The way sound propagates, or moves in water, is important for several reasons. Primary among these is understanding the effects of thermoclines, oxyclines, and the actual echo returns from fish or underwater structure and other suspended targets.

As one molecule forces the next to move, changes in the density of water can cause small consistent echo returns. Water which is colder has more closely packed molecules. When a sound wave passes from warmer to colder water some power is reflected as an echo. This results in the display of thermocline echo which is in general a flat line at a consistent depth. Oxyclines or oxygenated layers of water will produce the same results as will other various stratification of water layers. These include but are not limited to mud, sand, silt, and water outlets from dams, locks, creeks and rivers. Each of these situations can result in the water at different levels and for different reasons of temperature or composition, in the layering effect of water and the resultant layering of echo returns displayed on the sonar chart. Knowledge of these separate layers of water, the causes of them, and how bait and game fish relate to these layers can be of great benefit to the game fisherman.

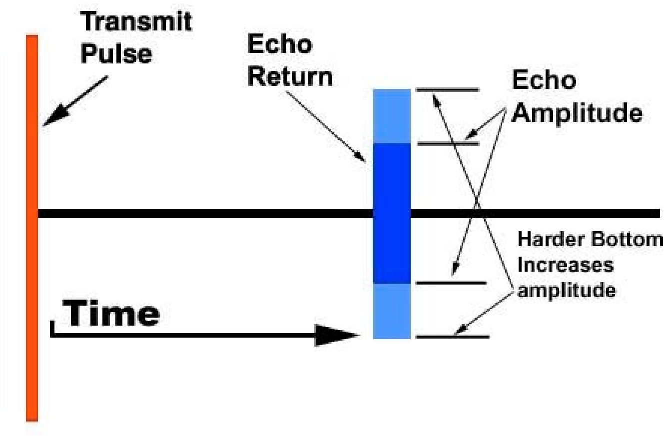
Note: *The acoustical properties of the flesh of a fish are very near that of regular water. This means the propagation of sonar waves through a fish are almost indistinguishable from open water. What causes the echo return from a fish is the presence of scales, skin, skeletal structures, and predominantly a swim bladder filled with air. Both fresh and salt water species have these bladders which are filled with air for buoyancy compensation at different depths. Experience has shown that fish that travel depths very quickly like Tuna or Albacore have very small swim bladders which make them more difficult for sonar to obtain good echoes. However other game fish like Bass, Walleye, and even the baitfish they prey upon all have bladders which are detected by sonar sound waves.*

Transmit and Received Signals

Determining the range or distance to the bottom, or to another target which returns a sonar echo, is all based on timing. We know that sound waves travel approx. 4800 feet per second. By timing the echo returns we can determine how far away an object is.

Note: *each sonar foot is equal to two linear foot, example: a ten foot bottom requires the sonar signal to travel ten foot down and ten foot back for a total of 20 feet.*

Received sonar signals are measured for both time and amplitude. This determines the actual range to a target and the relative signal strength of the echo. Signal strength is used to paint higher or lower intensity colors or grayscale patterns and grayline information about bottom hardness.



This picture depicts an actual sonar echo return as it appears after the receiver and before digital processing.

Echo amplitude can change while the echo stays at the same "time" or depth. These changes in amplitude are a result of harder or softer composition of bottoms. The resulting changes can be plotted as a Grayline or Colorline.

Note: *As shown Grayline and colorline are a function of echo signal amplitude or signal strength. A soft or mud & muck bottom at 10,feet, may return the same signal strength as a hard sand or rock bottom at 30 feet. Therefore the Grayline or colorline for each of these sonar charts will appear identical.* ***The primary purpose of Grayline or colorline is to illustrate "differences" in composition not identify them. This is used to separate bottom from structure, fish, and other things which may be at bottom or bottom distance from the transducer, but are not the same bottom materials.***

Frequency Considerations

The industry in general uses a range from 175 kHz to approx. 250 kHz. I am sure each manufacturer will believe their specific frequency is the most appropriate one as well. However, we feel the 190 kHz to 200 kHz range allows the best overall performance in the water types and depths most commonly fished by a majority of anglers.

High frequency sonar pulses in this range are primarily suited to relatively shallow water, less than 600 feet, provide superior target separation and detailed echo returns due to the shorter wavelength of sound. Low frequency, generally in the 50 kHz neighborhood, is better suited for deeper waters. These depths are generally only obtained in saltwater. The high power, low frequency, and long wavelength of this transmit pulse will allow the sound wave to penetrate deeper, with less dispersion from pressure or salinity than the higher frequency ranges.

Application

200 kHz is recommended for all freshwater applications to provide the best coverage and details. 50 kHz capability is recommended for saltwater in inshore coastal areas, deep saltwater (appropriate power and transducer), and inland freshwater operation in the great lakes areas. In freshwater 50 kHz can be used to track the depth of downrigger cannon balls and deep trolled baits when depth and not details are important.

Transducers

General Specifications

Sonar transducers are the bullhorn and ears of your sonar unit. But what exactly is a transducer, and what does it do?

In the field of electronics is a special device known as a crystal. It has some distinct properties. When a crystal is excited by an electrical field it begins to resonate or vibrate at a specific frequency determined by its internal properties. This same crystal, when vibrated, develops an electrical field or voltage.

The sonar transducer is a composite crystal material with these properties. When excited by voltage (transmit power), it begins to vibrate at the designated frequency. This physical vibration occurs with the transducer in contact with the water so the high power vibration or sound wave is coupled to the water. When sound waves or vibrations (echo return), strikes the face of the transducer, this vibration causes an electrical field or voltage to develop which is then coupled into the sonar receiver for processing.

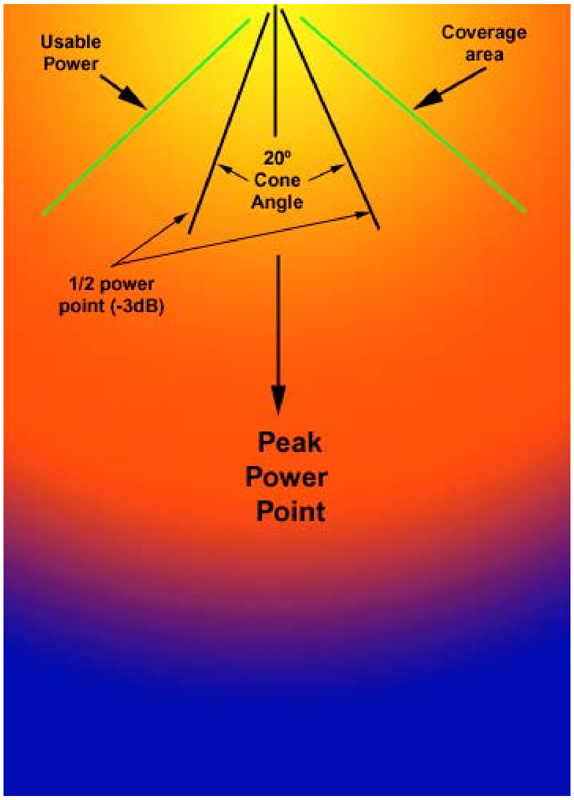
The sole purpose of the transducer is to couple sound waves into the water from electrical signals, and to then couple electrical signal to the receiver from sound waves. Sounds simple but I assure you we will complicate it in further sections.

Cone Angle verses Coverage Area

Cone angles and coverage areas are probably the area of most contention and the least understood of all sonar performance specifications. Lets try to shed some light on these numbers.

First comes the term Decibel or “dB”. We have neither the time nor the mathematical expertise to explain the exact nature of this unit of measurement. For our purposes, the single most important thing to understand is that a decibel is a unit which describes a **relationship** between two different **power levels**. This is used to describe the performance characteristics of a transducer element.

Transducers have manufacturing specifications which change certain performance characteristics of those crystal elements. Among those specifications are composite materials, diameter, thickness, and resonant frequency. In order to measure and distinguish between different characteristic elements, certain performance specifications are used. Primary among these is Cone Angle. The cone angle is actually an arbitrary measurement which relates little to actual sonar performance. It relates only to coverage in that a wider cone angle transducer will of course have a wider coverage area. It’s generally used only to identify different type of transducers. And that is accomplished as follows.



This diagram illustrates the relationship between Cone Angles and coverage areas as well as how this measurement is taken.

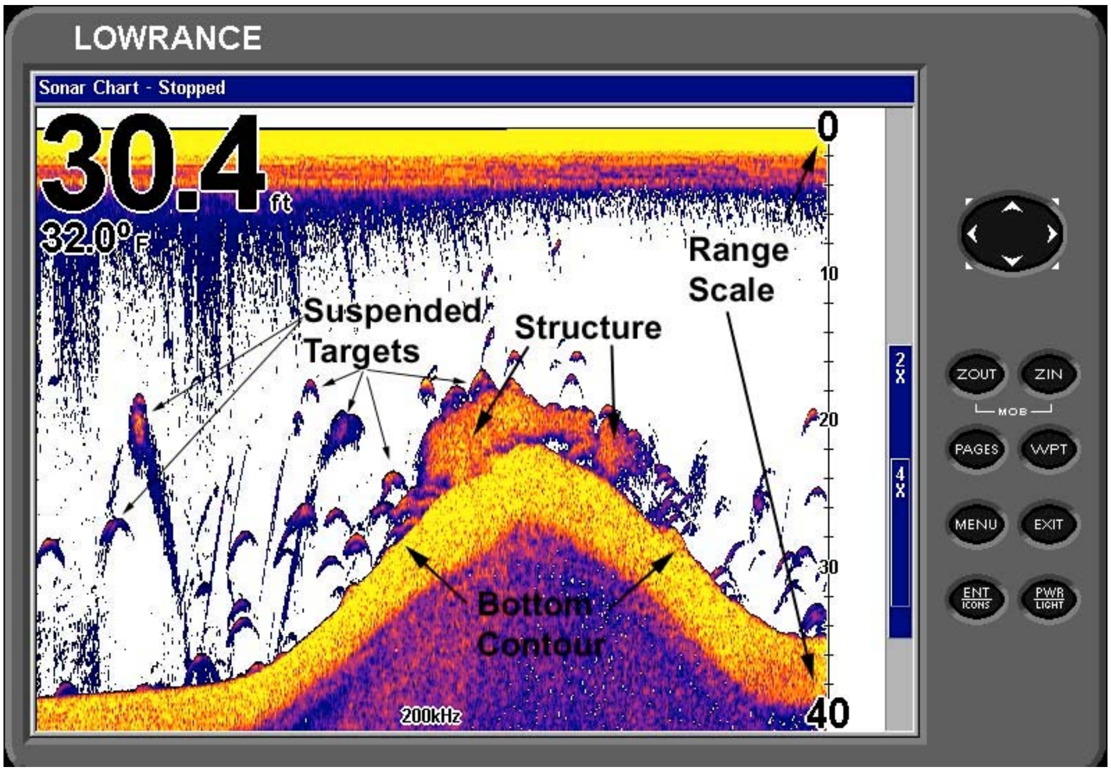
To measure cone angle you must first locate the Peak power point under the center of the transducer. Then you locate the Half power point (-3dB) on both sides of the peak power point. This is the cone angle which is used to identify the transducer element. Outside of the half power point in decreasing levels is still usable power. The other half of the total transmit power. Now the power weakens at an exponential rate the wider the angle however usable sonar power and useable sonar echoes are received up to 60º on our standard 20º cone angle transducer. That is why the cone angle is only a measurement to identify the transducer and does not indicate what will or will not be seen as an echo return.

Note: *All suspended targets will be marked up to the coverage area or even greater if close and shallow to the transducer. This concept is like the headlights on your vehicle. On a dark road you can clearly see the outline of your headlight beam where it lies on the pavement. Even with your headlight beams pointed towards the pavement enough light is produced to clearly illuminate even highway road signs which are 20 to 30 feet over the roadway. But clearly your headlights are not pointing in this direction.*

Sonar charts

What is really there…

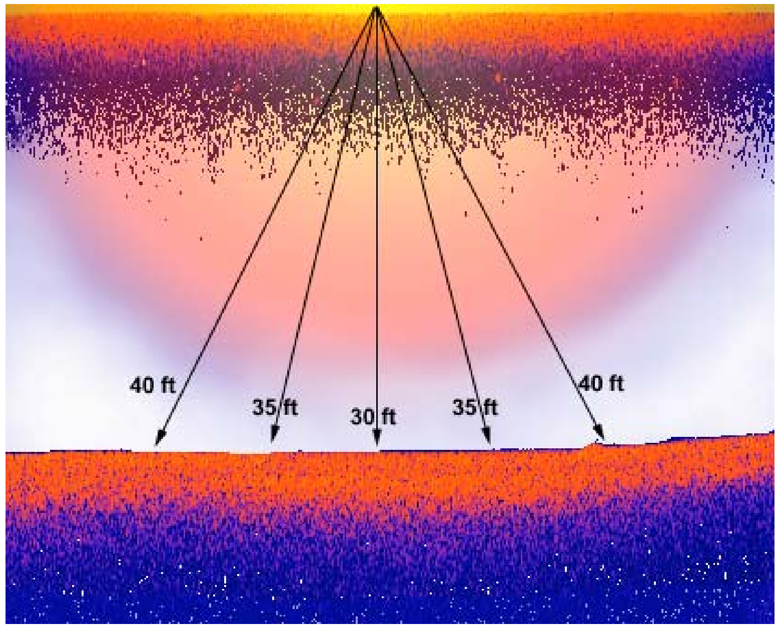
Ok… this is where the rubber meets the road and we begin to apply all we have learned about sonar principles. First lets reference the parts of a sonar chart display.



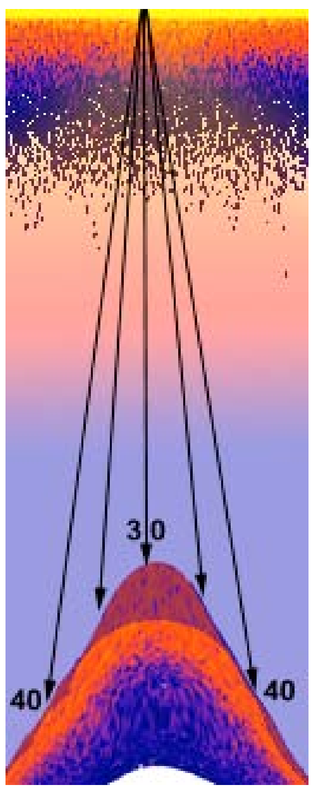
What and how does the transducer actually see the underwater world? First and foremost we must break the illusion of a 2 dimensional water world under the transducer. It is easy to be lulled into this interpretation as the actual sonar display is a flat 2 dimensional picture of a 3 dimensional world under our boats. The critical skills of viewing a 2D image of a 3D world, and converting that back to a 3d image in your mind can be an extraordinary benefit to all sport fishermen. This skill is based on several critical concepts when once understood or mastered will ultimately change the way you have always looked at your sonar chart and interpreted the images displayed there.

<u>Critical Concept # 1 :</u> The transducer is the "eye" of the sonar.

This is more true than most people realize. The transducer is an unblinking eye which views the water below your boat in a full 360º. Frontward, right, left, backwards, and all around. The actual view of the transducer is similar to a "fisheye view" where the closest point is directly below the transducer, and falls away on all sides. In referencing the lake bottom, what is forward, behind, or to either side of the transducer is increasingly farther away than what is directly below.



If a Sonar actually displayed every bit of every signal it transmitted and received it may appear like the following Illustration. Here it is more readily seen how what is forward rises to the transducer and what is behind falls away. At the point in which the actual bottom is closest, is determined to be the actual depth under the transducer and this contour is only charted when directly below the transducer. So even though structure or suspended targets may return echoes long before directly below the transducer, structure and bottom do not chart until the closest point to the transducer.

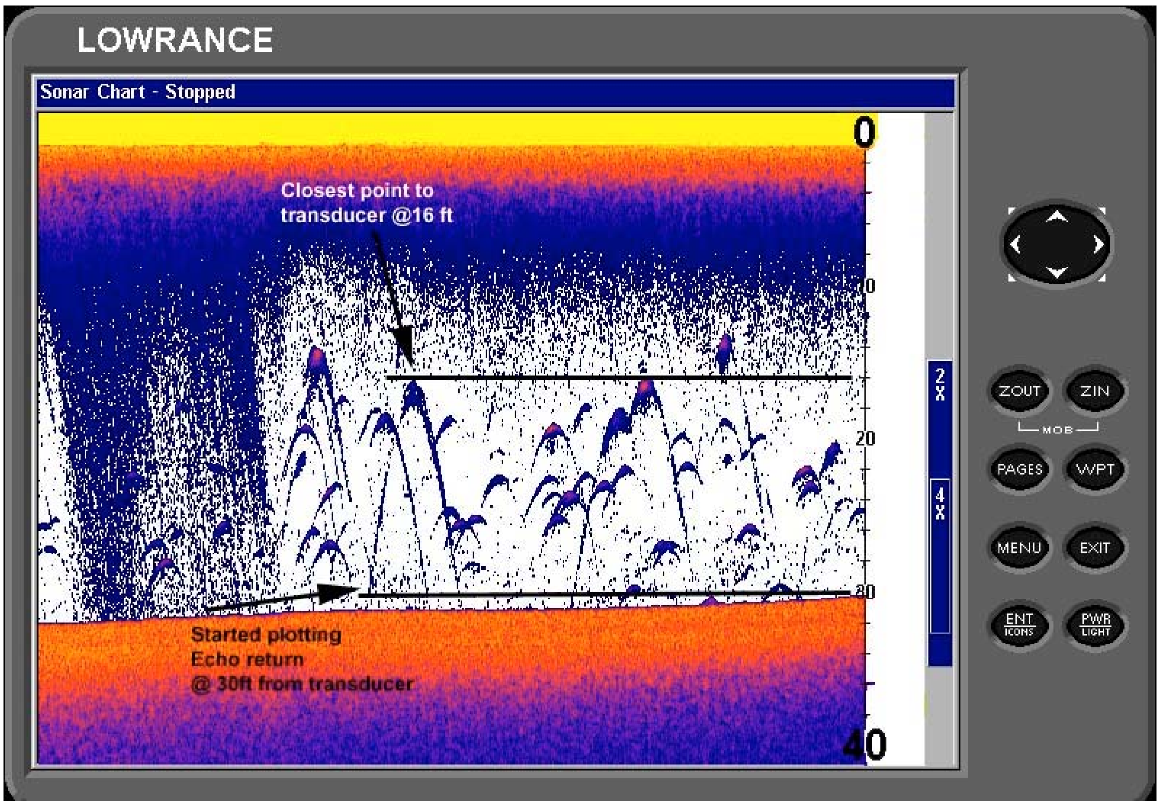


While you may begin to pick up the slightest echo returns from suspended targets which are farther away than the bottom, they do not chart on the screen until they are closer than the bottom as no details are plotted below the bottom contour line. The shape and strength of an echo arch can provide clues to where it is located relative to the center or nearest point of the transducer.

The peak of the arch does not indicate depth… It indicates only the exact range from the transducer to something which returns an echo.

<u>Critical Concept # 2 :</u> Range is not depth and depth is not Range.

The scale of numbers on the right edge of the sonar chart is called the RANGE SCALE for a reason. This scale refers to the distance from the transducer to something which returns an echo. The only time that depth is range, is when referencing the bottom contour. Only at this time, the distance from the transducer to "something" which returns an echo, are the same as the depth of water under the transducer. In all other circumstances the display of a sonar echo return feature can only be referenced in terms from distance from the transducer. Lets discuss suspended echoes or arches as we like to call them. What exactly is an arch and what do different arches tell us?



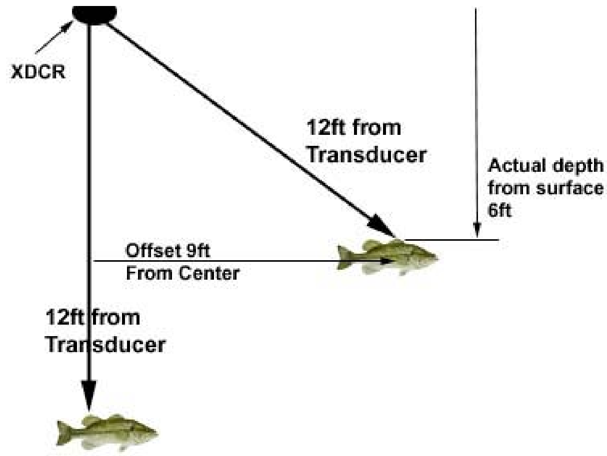
This chart shows the beginning of the arch, peak, and backside of a typical arch you may see on a sonar chart. With approx. 31 feet of water under the transducer to the bottom, the receiver detected another object which returned an echo. It began returning that echo when we were 30 feet away from the object. As we got closer to the target the echo trace moves up on the range scale indicating we are nearing the object. At the peak of the echo we are approx. 16 feet from the object before we begin to move away from the object and the plot of the echo moves down the range scale again until the echo is lost or it crosses the bottom. Whichever comes first.

<u>This does not mean the suspended fish was 16 feet deep. Only that at the closest point it was 16 feet from the transducer, while the boat was in 31 feet of water.</u>

Critical Concept # 3: Then how deep is the fish???

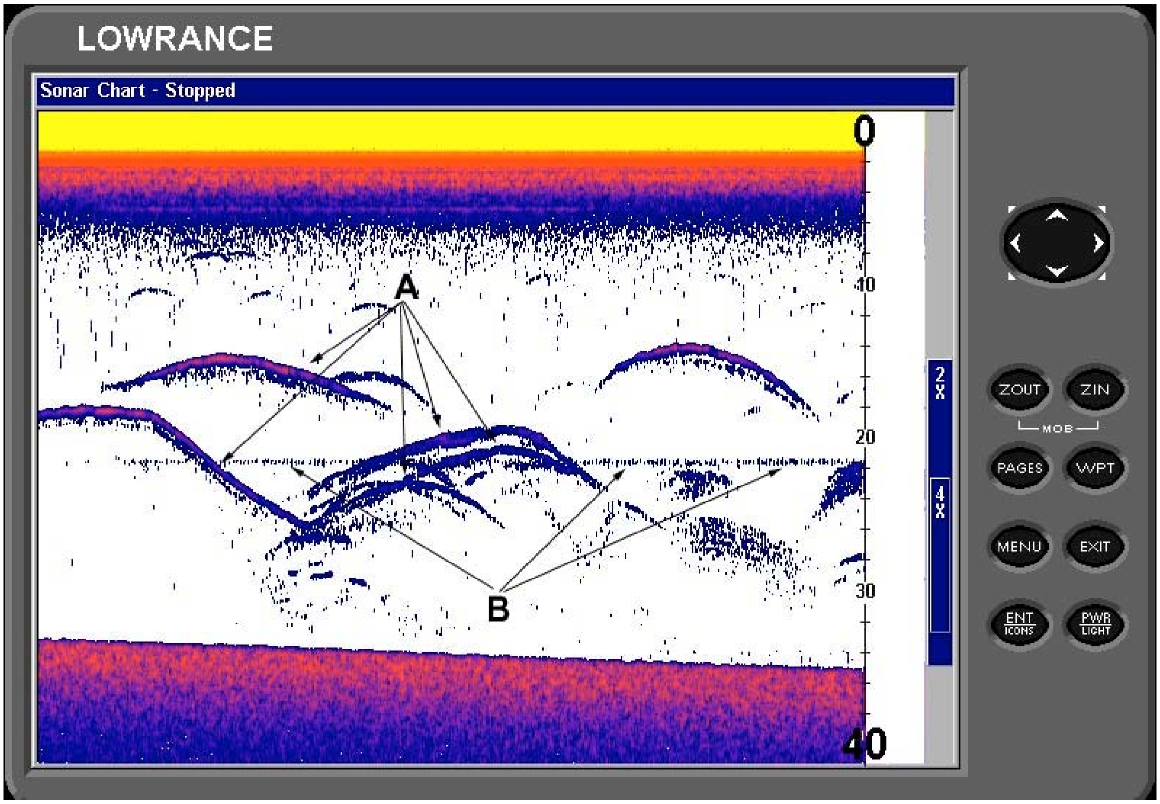
The depth a fish is holding cannot be determined by a sonar unit. The acronym SONAR stands for **SO**und **N**avigation & **R**anging. It is only capable of marking an echo return and indicating how far away from the transducer it is located. Now we can make educated assumptions based on our knowledge of coverage areas and proximity to other chart features like thermoclines or structure. But to specifically look at a suspended echo and say with certainty exactly what depth a fish is located is simply not possible. Lets Illustrate this.

When an arch peaks it indicates only the distance between the transducer and not the actual depth of the fish. As pictured here, a fish directly beneath the transducer may actually be at that depth. However a fish can be shallower and at some angle to the transducer where the actual depth of the fish from the surface of the water is very different than the distance from the transducer to the fish.



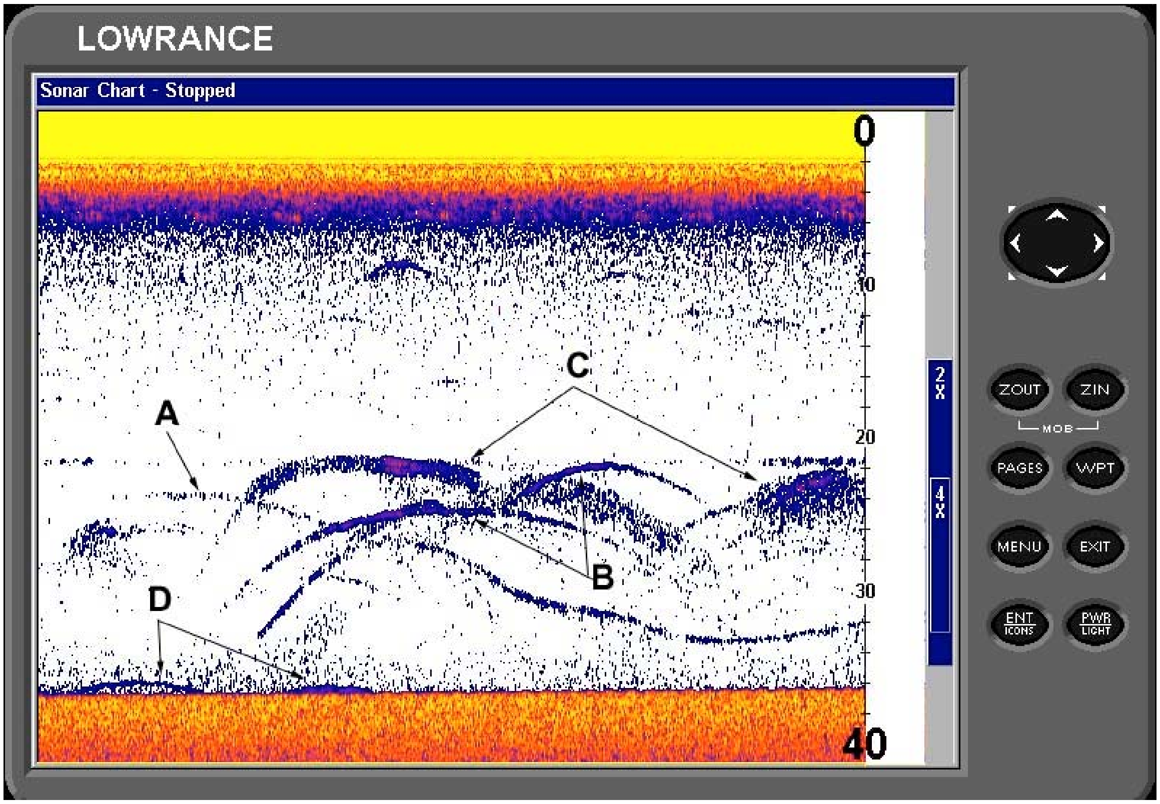
Relating the chart display to real world conditions

The following section contains real sonar chart recordings with real echo returns and a description of some of the elements and critical concepts which are indicated on the sonar chart recording. These are only a few examples of the many different chart details you may encounter while on the water.



A: This is a prime example of what is referred to as "streaking". This effect occurs when you begin to mark a fish arch, however reach a point where the fish notices the boat shadow, motor, or other stimulus and move rapidly away from the transducer. Remember, although the streaks go down, it doesn't mean the fish moved deep, only that they moved away from the transducer. They may have stayed at the same depth and simply showed their tail fins to the boat.

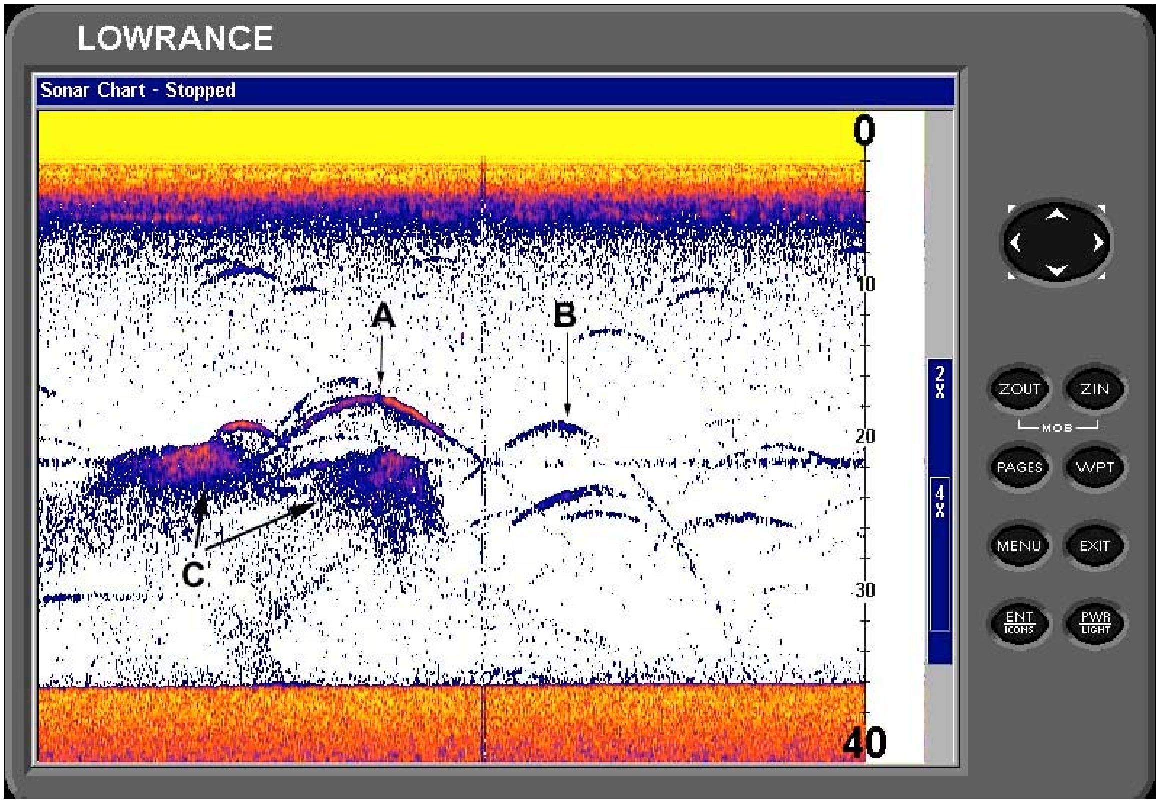
B: On this chart we can see the beginnings of a faint thermocline which has formed at approx. 22 feet. Even if faint it is important to note thermoclines and how the fish and bait are relating to these temperature differences.



A: Indicates the beginning of a track made by an active and moving fish. The "arch", if we can call it that, shows that although the fish moved a little farther away from the boat it did for a while actually parallel the boat. It may have been inspecting our trolled live bait.

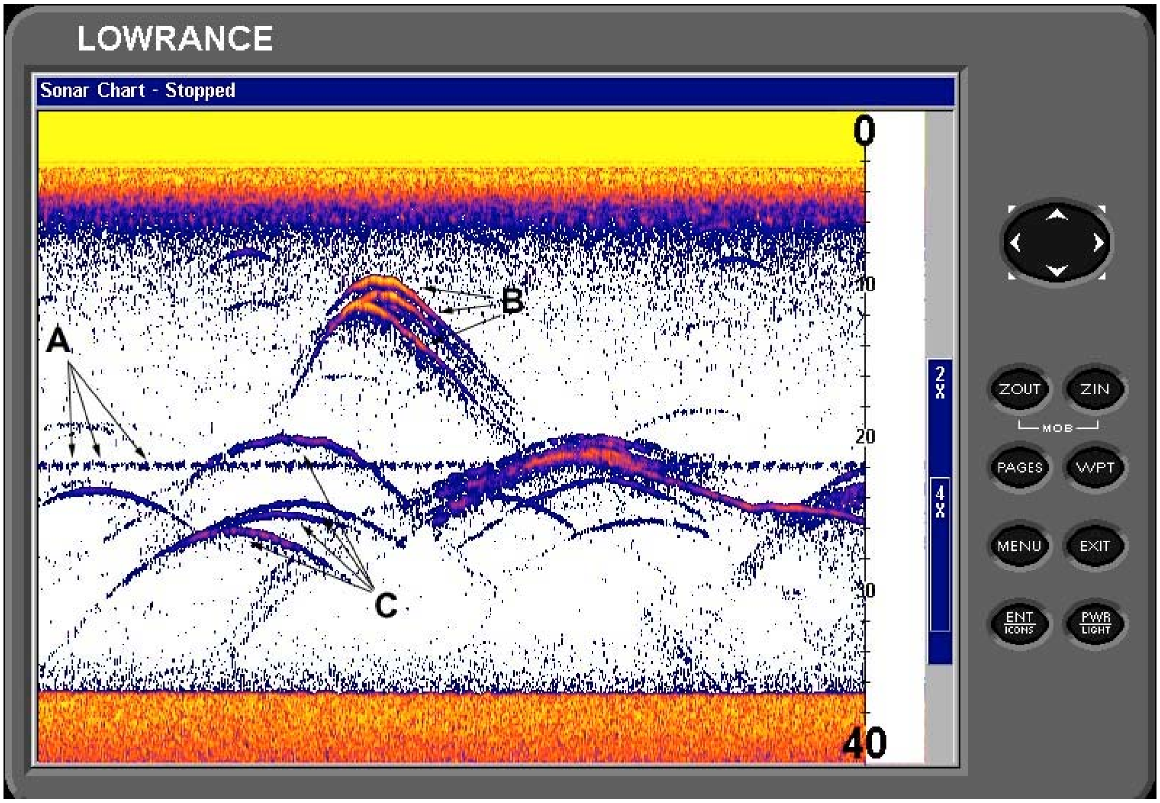
B: Interspersed around the active fish are less active fish which would rather sit still than move around. This results in relatively clean rounded arches. This flat rounding of the arch may also indicate the fish is closer to straight under the transducer. Without going into the mathematics of bisecting cone shapes for face area, a good rule of thumb is a fish arch becomes sharper or pointed the farther from center the echo is. So sharp pointed arches indicate fish on the edges of the coverage areas and rounded flatter arches are more directly under the transducer.

C: Smaller schools of bait fish can also produce or be displayed in an arching pattern. But as displayed the peaks of these arches show color indicating good return signal strength while also being dispersed. In some cases it can become possible to actually see arches from individual baitfish.

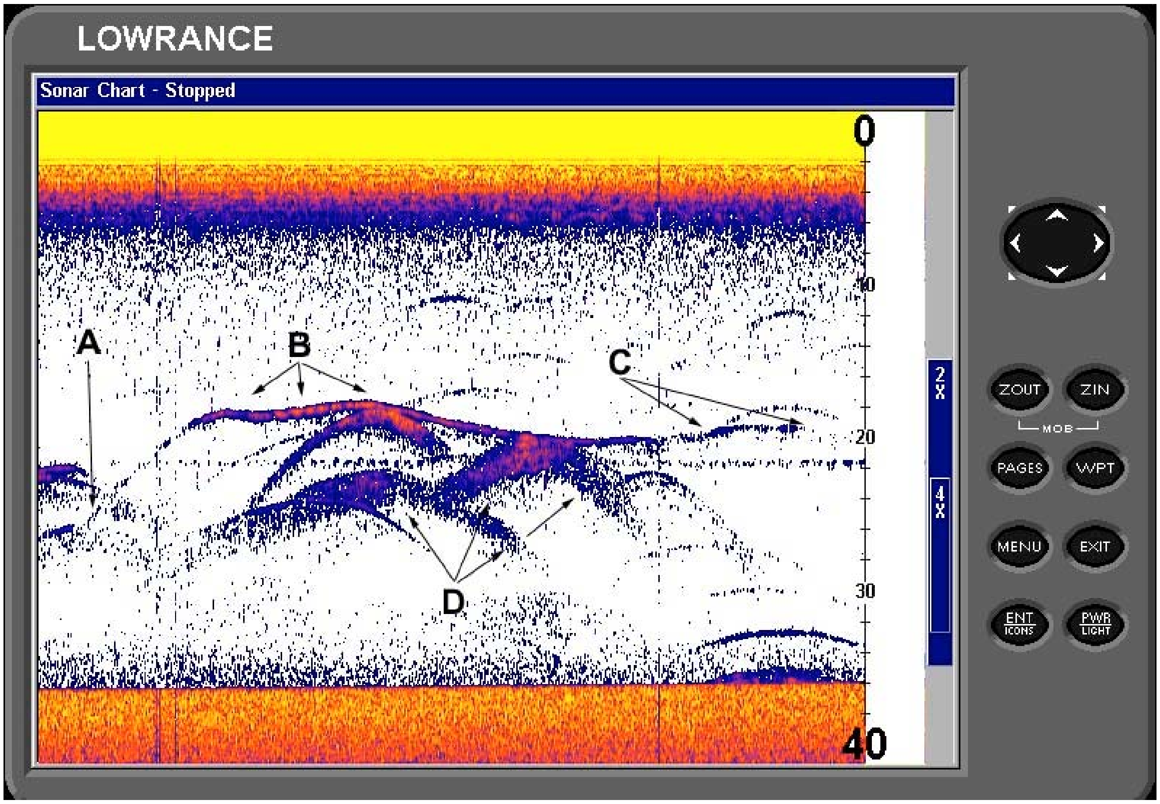


A & **B**: This chart is a good representation of the difference between a fish under the transducer and one on the fringes of the coverage area. A-arch shows color which indicates return signal strength and it is also well rounded with an even length of arch closer and arch away. B-arch shows a slightly more pointed appearance to the peak and this echo is weaker showing only the faintest of echo returns. This indicates this arch was generated be a fish closer to the edge of the coverage area and A was generated by a fish closer to directly under the transducer.

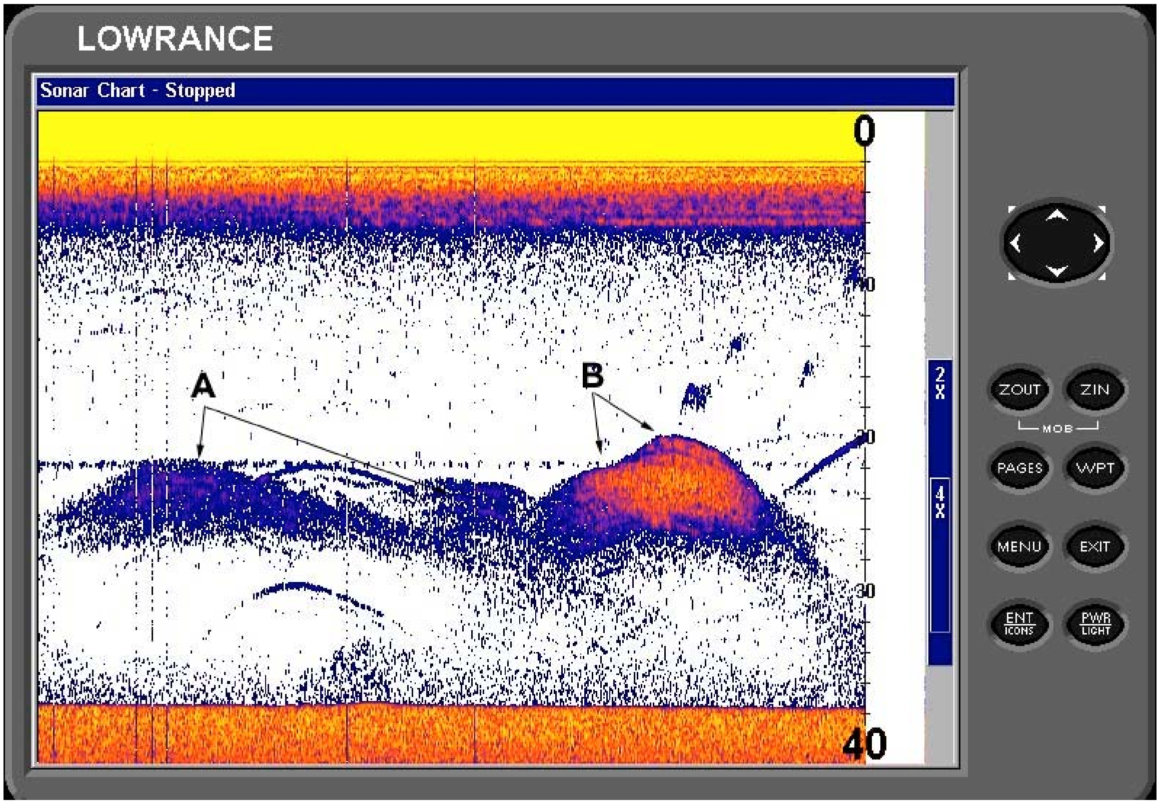
C: indicates balls of baitfish. Both are relatively the same size schools of bait and we would assume the same size baitfish. The first shows more color in the center indicating more echo signal return strength and the next one is weaker. The second ball is also depicted a little farther away or lower on the range scale. This may indicate a ball of bait which is not as close to center under the transducer as the first bait ball.



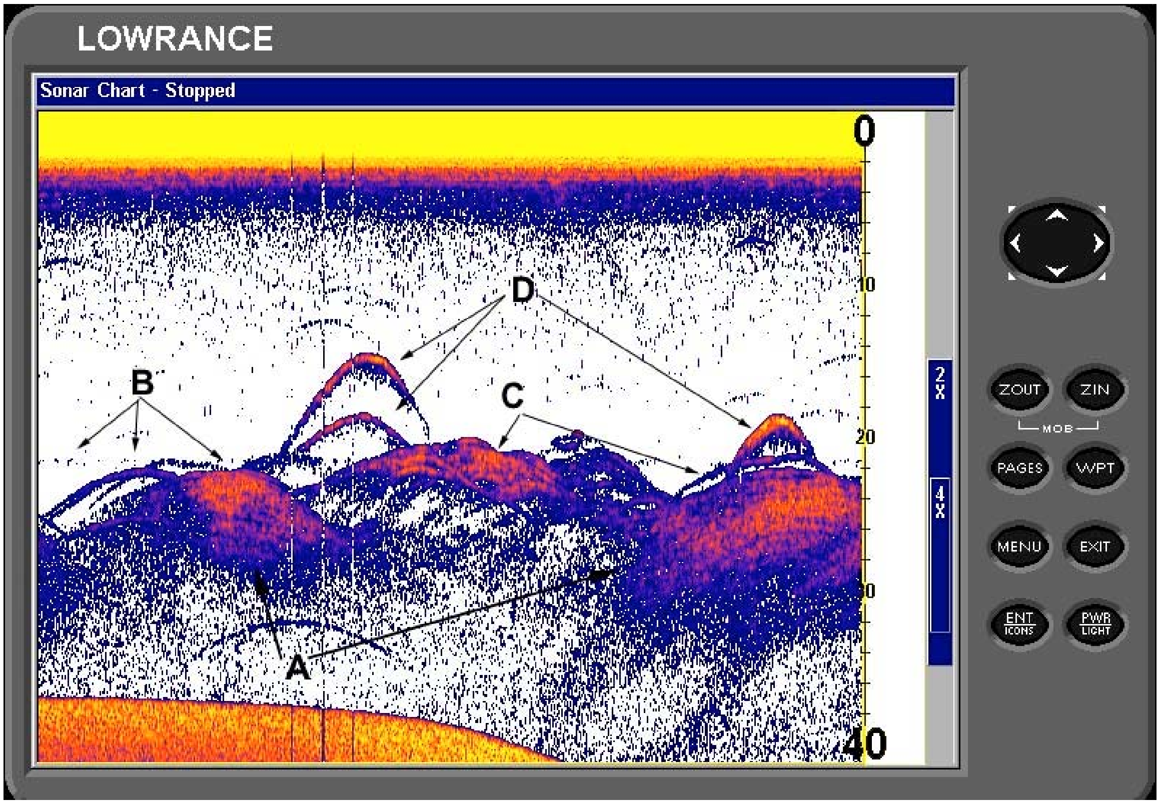
A: Depicts the thermocline. In this portion of the chart it is easily seen, in others it is not. You may have begun to notice that most of the activity is very close to this thermocline. This chart also shows active fish (**B**:) closer to the surface which streak away when we reach a distance of approx. 10 feet from them. Other deeper inactive fish (**C**:) are not disturbed by our trolling approach.



A:, **B**:, and **C**: all indicate an active, moving, and probably feeding fish. A: is the point in which this fish first began to return an echo. This was approx. 26 feet away from the transducer when it began returning an echo. During B: was its two closest points at approx. 18 to 20 feet. It also paralleled the boat for a while maintaining a distance of approx. 20 feet for about 15 to 30 seconds before peeling away into nothingness. D: Note the schools of baitfish, which are small and have that arching appearance. More importantly however is the fact that the bait always seems to associate closely with the thermocline.



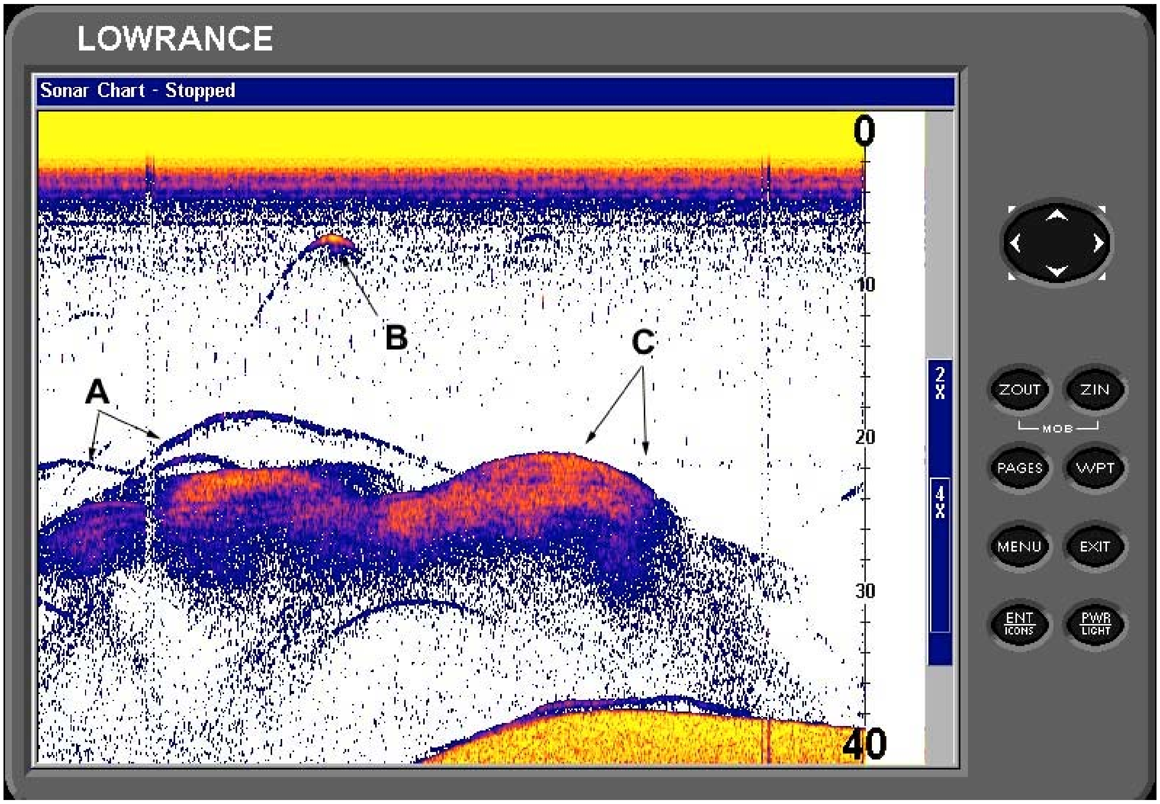
A: & B: Another good contrast of schools of baitfish. A: is faint broken, and shows no color. These bait are closer to the edges of the coverage area than B: which is depicted by a densely packed ball returning a lot of echo signal strength and showing color. Now we begin to see the bait is associating either right at or just below the thermocline. We can only guess if the bait are being driven up into the thermocline or down into it by the game fish, but at the thermocline they are.



This is what we call JACKPOT. Open water bait fishing rarely gets better than this.

A: indicates the baitfish which are schooled up in large quantities like a buffet table. **B**: is the thermocline showing where the bait is congregating.
C: shows active moving and probably feeding fish while the arches depicted by …
D: seem to indicate fish which are less active.

Probably already bellied up to the buffet table and are taking a breather, before going back for desert.



A: indicates active, moving, and feeding fish.
B: The transducer actually came within 7 or 8 feet from this fish and the arch would indicate this fish was fat, dumb, and happy and couldn't be bothered to move after his meal.
C: Shows the bait and the thermocline they are relating to.

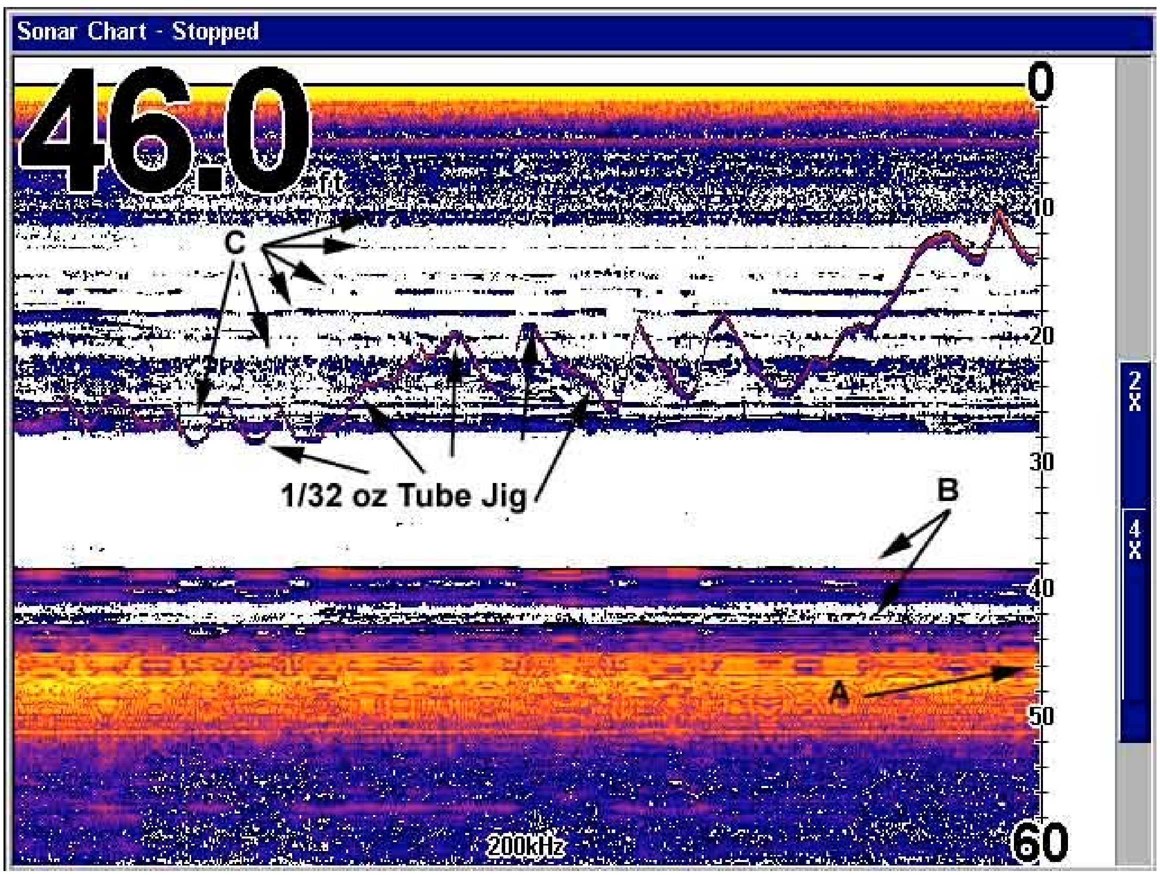
Special thanks and consideration go to our friend Mr. Hugh Hamilton, Hamilton Guide Service, Garfield Ark. Covering Beaver lake and the White river.

More Real world Charts

Chart differences based on mode of operation and color.

The sonar chart display will change based on boat speed, sonar repetition rate, and color modes. Not all fishing is done while trolling at a set speed over schools of baitfish and game fish. The previous illustrations are to represent examples of sonar principles in operation. Now that the operational model has changed that doesn't mean the principles change. The same rules apply so lets look at some obvious different displays.

First is the stationary sounder. This type of chart will occur when drifting slowly or even fishing form a fixed dock or pier using a portable type sounder. The following chart was recorded from a fixed location on a fishing dock over one of my favorite crappie holes. First thing you notice is the lines are all flat and straight. As you slow down to a stationary position sonar begins to shoot the same targets over and over. The same targets return the same echo over and over. Thus resulting in the same chart information displayed on the chart over and over again producing flat the line characteristics.

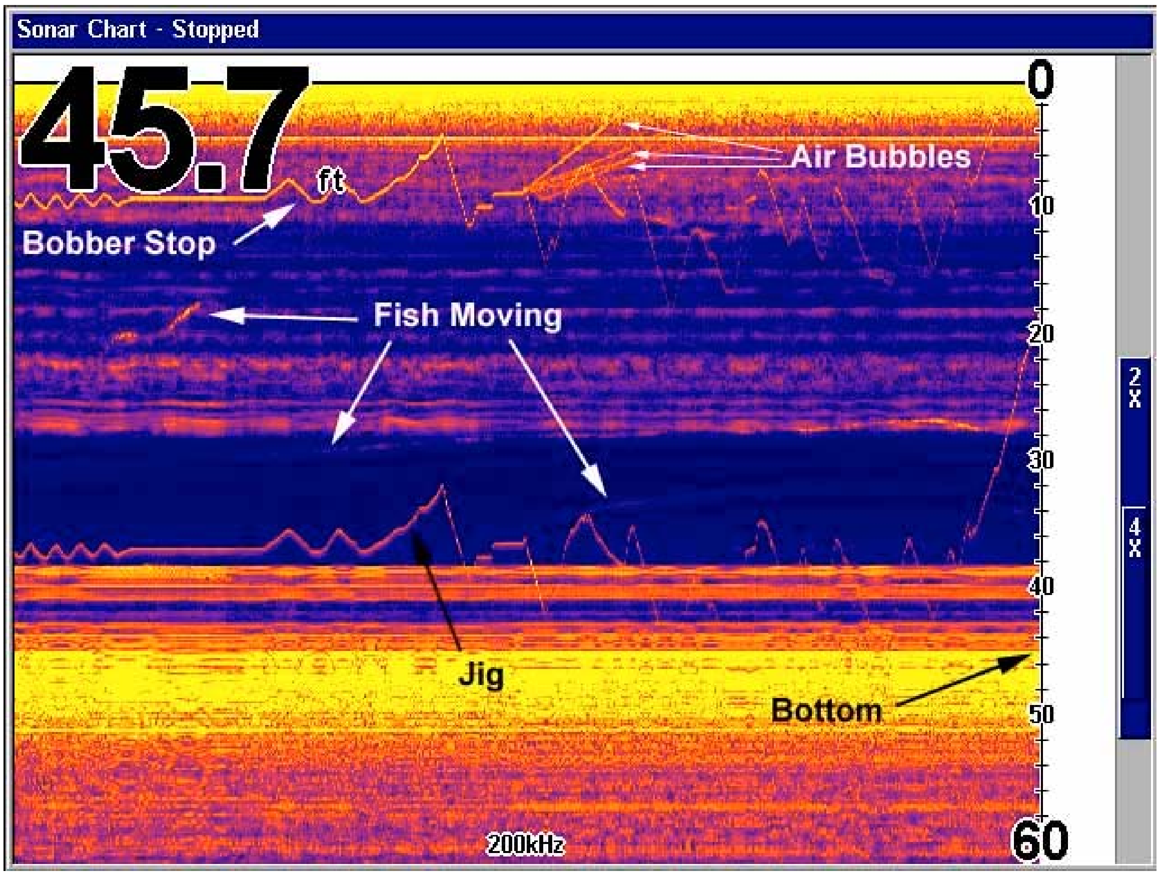


A: Denotes actual bottom under the transducer. B: indicates softer echoes from brush pile directly below the transducer. C: indicates stratified layers of water which are a combination of thermocline and oxyclines. The track going through the chart is a 1/32 oz. Tube jig moving vertically closer and farther away from the transducer.

So in the previous chart we are dead stopped, the sounder bangs away, and returns the same echo's, paints the same display which results in flat line charts. The only thing changing is the jig as it comes closer and falls away from the transducer. This is KEY.

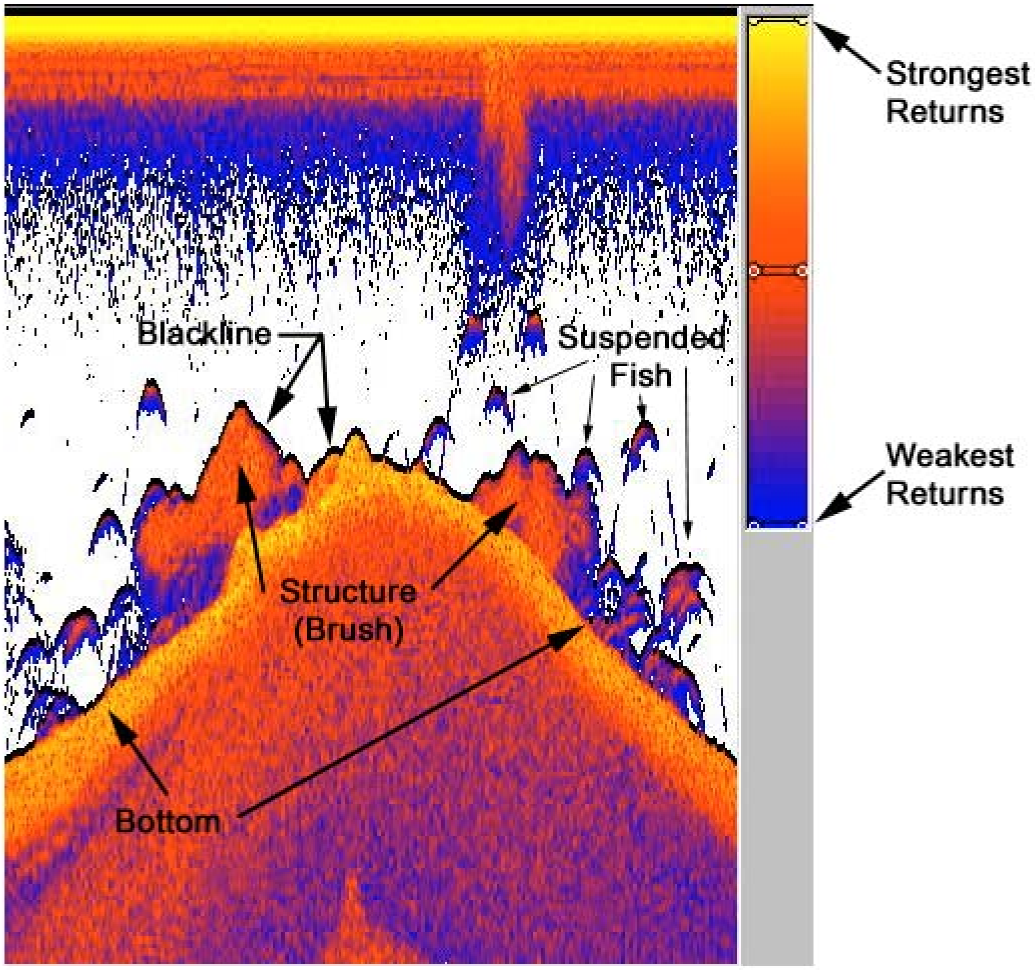
Critical concept # 4 :Where are the Fish?

When sitting still and nothing is moving on the sonar chart then a fish is represented by line which move. This can be lines which come and go, change depth, or any other movement can indicate an active moving fish. From the above chart lets turn up the sensitivity a little.



This chart shows the jig moving up and down. It also shows three sonar echo's which may indicate moving fish. The first is obvious at about 18-20 feet. The others just below the thermocline and just above the jig are more faint returning less sonar echo which mw indicate they are closer to the edges of the sonar coverage area. Of particular note on this chart is the rubber bobber stop which was set to between 25 and 30 feet is represented by the top chart track which mimics the jig's movements. You will also notice the bobber stop was tracked to nearly 20 feet. The tracks left by rising gas are typical in that it is represented by a smooth and steady upward track. An object dropped by or near a transducer which sinks will leave a similar downward moving sonar track.

Do I Need Color?

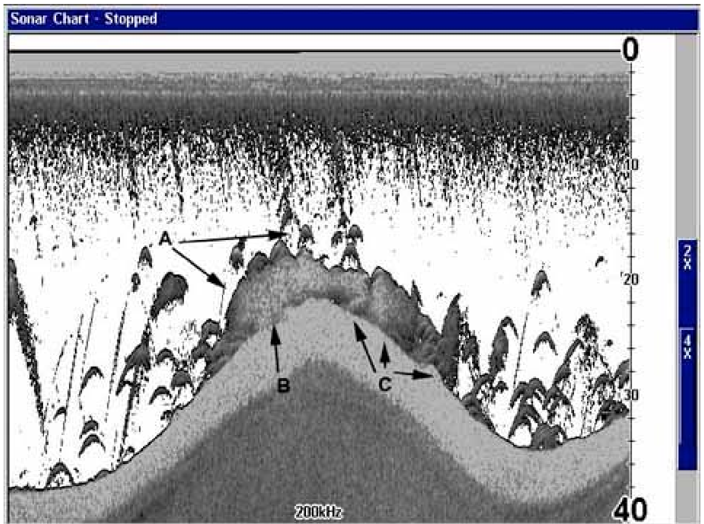


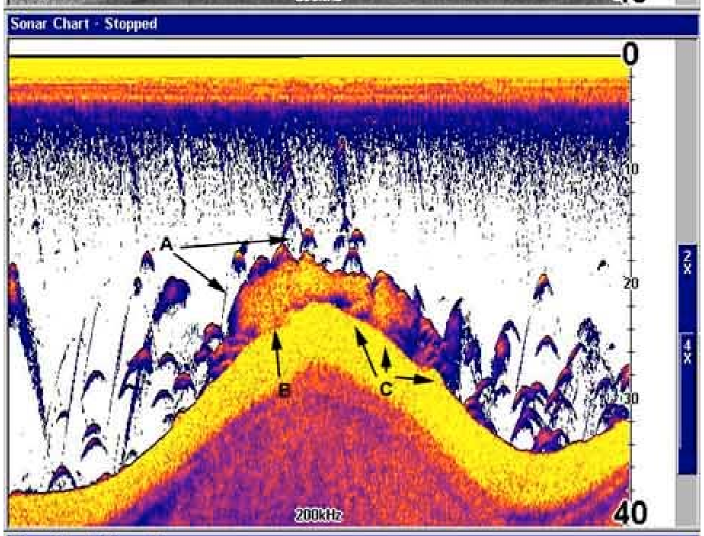
LCX Color Scale.

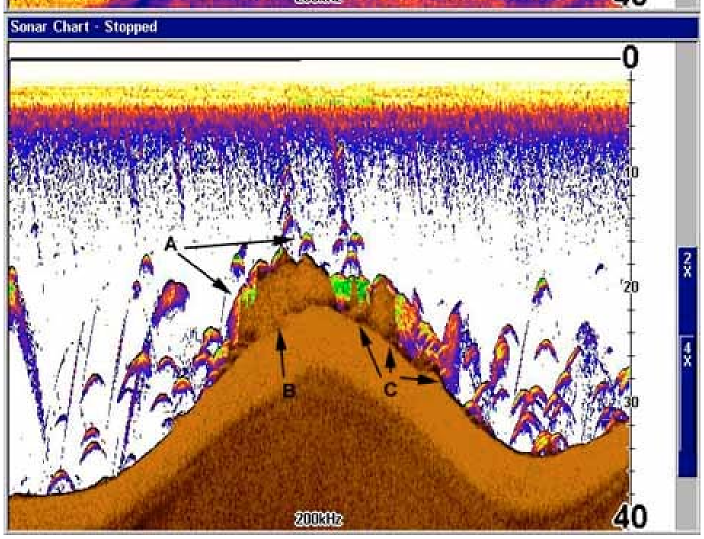
The colors depicted on a Lowrance Color unit are related to the strength of the sonar signal return or Echo strength. In this scale the Echo returns are depicted in a color spectrum with the strongest returns depicted bright Yellow, medium returns depicted Red, and the weakest returns depicted Blue. The Blackline of the display indicates the bottom surface. (As Pictured Above).

The color below the blackline the “Colorline” and functions the same as “Grayline” in the monochrome displays. The color indicates the strength of the returns and is primarily used to distinguish between what is bottom, and what is bottom structure. In the illustration above notice the bottom includes some yellow color while the structure (brush) is depicted mostly red. This indicates the structure is returning less signal than the bottom and is therefore distinguished from the bottom.

Use of the “Bottom Tracking Color Mode” changes the bottom to an arbitrary color which is not in the power spectrum This allows the unit to display suspended fish inside of structure for the best possible definition, detail, and accuracy.



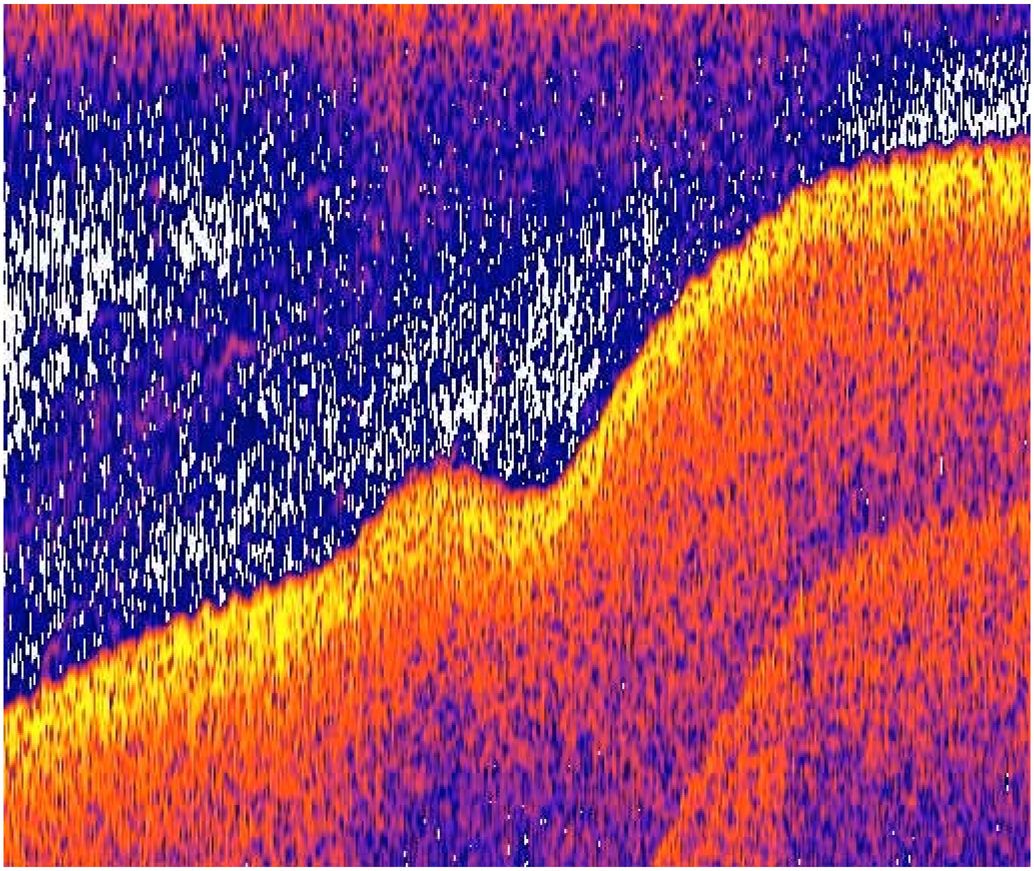




The same chart is pictured here at the same resolution, same sensitivity, and other chart settings. A: denotes suspended targets of bait fish and game fish in and around some type of bottom contact structure. B: indicates structure attached to bottom which is similar in echo return blurring the line between bottom and structure on bottom. C: shows a hard bottom contour indicated by clean hard color separation from structure above.

In color mode, the features of the display become more refined, as differences in echo returns are more easily seen. Color scales are more easily interpreted as yellow color from red and red from blue are easier to see than gray and a lighter shade of gray. This mode provides more accurate and detailed information about differences in targets and differentiation of targets than can readily be seen in Grayscale modes.

In bottom tracking color mode we change the color of bottom and structure on the bottom to a color not included in the spectrum from hottest echo to weakest echo. This completely separates what is bottom and what is bottom structure from all suspended targets. It also ensures not suspended target will be confused with or thought part of the bottom or bottom structures. In the area of C: we can even see structure near straight under the transducer but not directly below producing a hard bottom and depicting bottom structure.



This chart has the appearance of a jagged bottom contour. As if the bottom was chiseled out of splintered stone or growing fissures. In actuality this chart was recorded over a flat, featureless, smooth, hard sand bottom. It was also with a transducer on a very narrow beam aluminum hulled “V” bottomed boat. This boat was prone to a lot of movement and the result is as pictured.

As the boat has a narrow beam, and only approx. 14 foot from stem to stern, it moves significantly in the water. Roll when sitting still (side to side) and pitch when moving slowly (front to rear). This creates a lot of vertical movement of the transducer attached to the transom, which changes the distance to the bottom, and results in a jagged bottom chart as pictured. This change from sounding to sounding may only be 3-5 inches but as seen it is all displayed accurately as measured.