How to get the most out of Loran-C

Another title in the series

Marine electronics

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Loran-C is here. It already covers the West Coast, some Hawaiian waters, and much of the East Coast. By spring 1980 Loran-C service will be available to all coastal waters of the U.S. mainland (except the North Slope of Alaska), to the Great Lakes, and to much of the land area of the U.S. as well.

Since Loran-C replaces Loran-A, many mariners have switched or will switch to Loran-C. Other mariners will start using Loran-C. Let us assume you have a Loran-C receiver. Naturally, you want to get the most out of it. You want to put Loran-C to work.

This bulletin is written for you; it assumes that you have a basic familiarity with Loran. If you have not operated with Loran-A or Loran-C, and want to do some background reading on Loran, see "For more information" for suggestions. And if you have not yet chosen a receiver, you may wish to read What You Should Know About Loran-C Receivers *(see "For more information").*

These are the main topics you will find covered in this bulletin:

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Oregon State University
Extension Marine Advisory Program
A Land Grant / Sea Grant Cooperative
SG 54 June 1979

Accuracy

Navigational accuracy is vitally important to you. Accurate navigation can save you time, make you money, keep you safe. The more proficient you become in using Loran-C, the greater will be the benefits you derive from this navigation system.

But just what is "accuracy"? There are different types, and you should understand the differences.

The Loran-C system has various factors that collectively determine the accuracy of your position: transmitters, the atmosphere through which the signals travel, receivers, charts, and you, the operator. Each component contributes a small error; that is, each component has its own individual accuracy limitation. Overall, system accuracy is the result of the combination of the individual accuracies of all these components. The signal that reaches you is stable and highly accurate. What you do with it determines the final accuracy you will achieve.

You need a good-quality receiver that has been correctly installed and uses a proper antenna if you want to realize the full benefits of Loran-C. How you operate your receiver and plot your position is also critical. You should also be aware that you lose some accuracy in translating Loran-C coordinates into latitude and longitude. The following explanation assumes that you have a good receiver, correctly installed, and that you properly operate the receiver and properly plot your positions.

Absolute accuracy is a measure of your ability to determine your geographic position—latitude and longitude—from a navigation system such as Loran-C. (To help you understand technical terms, those that are *italicized* in the text are defined in the glossary.) The absolute accuracy of Loran-C varies from 0.1 to 0.25 nautical mile (using standard nautical charts), depending on where you are within the coverage area. You would use absolute accuracy to keep track of your true position if you were crossing an ocean or visiting a new location.

Repeatable accuracy is a measure of your ability, through using a navigation system such as Loran-C, to return to a position where you have been before. Repeatable accuracy helps you to return to the same spot, time after time, by using the Loran-C readings for that spot as a reference. The repeatable accuracy of Loran-C varies from 15 to 90 meters (50 to 300 feet), depending on where you are within the Loran coverage area.

To some mariners, repeatable accuracy is even more important than absolute accuracy. It takes advantage of the full capabilities of Loran-C and is useful in many ways. If you fish commercially, it is repeatable accuracy that helps you avoid "hangs" or bottom obstructions, return to a known area of good fishing, and find your pots in a blinding fog. It is also repeatable accuracy that helps you find the sea buoy, if you have previously determined its Loran-C coordinates, and return safely to port when visibility and ocean conditions are poor.

Installation

Selecting the right Loran-C receiver and knowing how to operate it properly are both very important. However, the best Loran-C receiver with the best operator is useless unless you have your receiver installed properly.

Just because a Loran-A receiver worked on your boat, do not expect that a Loran-C receiver will work equally well without special attention to installation. Loran-A operates in a higher radio frequency band than Loran-C. Both interference and antenna placement require special attention with Loran-C (Loran-A receivers are less susceptible to local, boat-generated interference, and antenna placement is less critical).

There are many well-qualified marine electronics dealers who have undergone factory training in Loran-C installation practices. On the other hand, the dealer installing your set may also handle radar, VHF-FM communications equipment, depth sounders, etc. He cannot be expected to know everything about such a myriad of equipment. This section points out the critical aspects of receiver installation and indicates how you can assist the technician who installs your receiver.

Antenna location. The best choice for the antenna location is as high as possible—and away from all stays, metal masts, and other antennas. If the Loran-C antenna must compete with other antennas (for instance, VHF-FM) for the top of the mast, you may put it in a lower location—but keep the Loran-C antenna in the clear, away from metal objects. Locating the antenna in the vicinity of metal stays can cause a reduction of up to one-half the strength of the Loran-C signal at the receiver. One approach, if you are in doubt, is to install the antenna temporarily and try the receiver. If it works well, the antenna and coupler can be permanently mounted at a later time. Do not share the Loran-C antenna with any other equipment. Use only the antennas recommended by the manufacturer of your receiver.

Grounding. Equal in importance to antenna location is proper grounding of the antenna coupler and receiver. On metal boats this does not present a severe problem; a ground strap can be attached to the hull. On wood and fiberglass boats, however, providing a proper ground can be difficult. Ground the receiver and coupler to the engine block with a 2.5-centimeter (1-inch) copper strap.

Interference. On power boats there may be a great deal of electronic interference, or noise, generated by the engine (particularly gasoline engines), auxiliaries, and alternator. Many types of electronic equipment also produce interference. All of these sources of interference can inhibit proper operation of your Loran-C receiver.

Many receivers are equipped with a meter for adjusting the *notch filters*. If your set has one, a quick method of checking for local interference is to tune the meter across the band. If the meter indication remains high, you probably have strong local interference. Many sets have built-in tests for displaying *signal-to-noise ratio (SNR)*. Use these tests during installation and as a quality check later on. *The Noise Book* (see "For more information") has a detailed discussion of noise, its causes and elimination.

One often overlooked source of electronic interference that can overwhelm a Loran-C receiver is a television receiver. Television sets produce signals near 100 kHz. These radiate in the vicinity of the set and can cause interference in other electronic devices. Therefore, avoid installing your Loran-C receiver near a television receiver.

Receiver placement. A Loran-C receiver is a valuable aid to navigation. Locate it where it is convenient to your chart table or navigation position. Some receivers use lights to warn of system or receiver malfunction. If yours has these lights, locate your receiver so they do not reflect off the pilot-house window (and thereby reduce your night vision).

Protect your receiver from excessive heat, dampness, salt spray, and vibration. Do not mount it in direct sunlight or within 1 meter (3 feet) of your magnetic compass. Provide adequate ventilation.

Use of Loran-C system

To get the best results from Loran-C, you must decide which *chain* and *secondaries* to use.

Selecting the chain. What chain should you use? One step the operator must perform on almost all Loran-C receivers is selecting the chain or rate to be tracked. Some receivers use the old designations, such as SH7, while others use the new designations, such as 5930 (see table 1).

On the West Coast from Oregon to southern California, only one chain is available. On the Washington and Alaskan coasts, and in some areas on the East Coast, however, there is overlapping coverage from two or more chains; in these waters, you must select the best chain available.

In selecting the preferred Loran-C chain, consider:

1. **Destination.** Whenever possible, select a chain that you can use for the entire voyage. This allows you to "lock on" the receiver prior to departure and, assuming your receiver has the capability, put it in the "track" position for the entire trip. This is the preferred method of operation; it minimizes the effects of interference on your receiver.
2. **Adequacy of secondary stations.** The choice of chain to use also depends upon which chain has secondary stations offering the greatest potential for accurate navigation. See "Selecting the secondary stations" in the next section.

Table 1.—*Existing Loran-C chains (rates)*

New Designation	Old Designation
9990	SS1
9980	SS2
9970	SS3
9960	SS4
9950	SS5
9940	SS6
9930	SS7
9920	SS8
9910	SS9
7990	SL1
7980	SL2
7970	SL3
7960	SL4
7950	SL5
7940	SL6
7930	SL7
7920	SL8
7910	SL9
5990	SH1
5980	SH2
5970	SH3
5960	SH4
5950	SH5
5940	SH6
5930	SH7
5920	SH8
5910	SH9
4990	S1
4980	S2
4970	S3
4960	S4
4950	S5
4940	S6
4930	S7
4920	S8
4910	S9

3. **Interruptions of service.** In some areas there may be local interruptions in service that prohibit use of one of the chains or one of the secondaries. Interruptions of service are normally short; they are announced on Coast Guard broadcasts and published in *Local Notice to Mariners.*

You can obtain information on the preferred chain to use in your area from your local Coast Guard District Office (see "For more information").

Selecting the secondary stations. Once you have selected the best chain, how do you pick the best secondary stations? Loran-C chains have been designed to give a two *line-of-position (LOP) fix*. Each *master*-secondary pair produces one LOP. In some areas, a third usable LOP is available. While some Loran-C receivers track more than two secondaries, the majority of receivers now available are limited to two. Here are some guidelines for selecting the best two master-secondary pairs:

Gradient. This is the most important consideration and is best illustrated through an example. Consider figure 1a. Look at the Y lines (the letters W, X, Y, and Z are used to designate the different master-secondary pairs). You can see that the distance between the two Y lines is 1 nautical mile, or about 2,000 yards. (This conversion from nautical miles to yards is traditional and handy but not exactly accurate.)

Now, the spacing between the Y lines is 10 *microseconds* (millionths of a second), so 1 microsecond for the Y lines in this area is thus equal to about 200 yards. You might reasonably expect an error in your Loran reading of ± 0.1 microsecond, which would correspond to ± 20 yards in this case. Similarly, looking at the X lines, you might expect an error on the order of ± 40 yards, given the same 0.1 microsecond error in reading.

Now look at figure 1b. Here you see much larger gradients for both sets of lines, and your anticipated errors with 0.1 microsecond readout error will be ± 180 yards on Z lines and ± 240 yards on W lines. Given gradients such as shown in these examples, you should choose the X and Y secondaries in preference to the W and Z secondaries. Note that with a large gradient, small changes in time difference give a large change in position.

Crossing angles. Ideally, for the most accurate fix, you would choose two lines of position that intersect, or cross, at right angles. Since this is almost never possible, select the pair of LOP's with a crossing angle closest to 90° (assuming equal gradients in all cases). The lines in figure 1a cross at an angle of about 70°, an almost ideal situation. In practice, you should be wary of a fix where the LOP's cross at an angle less than 30°; the lines in figure 1b cross at an angle of about 30°.

Baseline extension. Never use a secondary station in the vicinity of its *baseline extension* (see figure 2). Near this line, the gradients become very large. Also there is a possibility of introducing very large errors in position because you may not be able to tell which side of the *baseline* you are on. The baseline extension is labelled on charts.

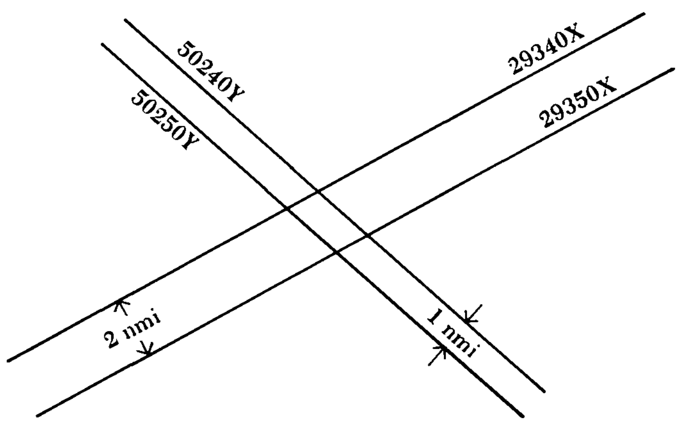
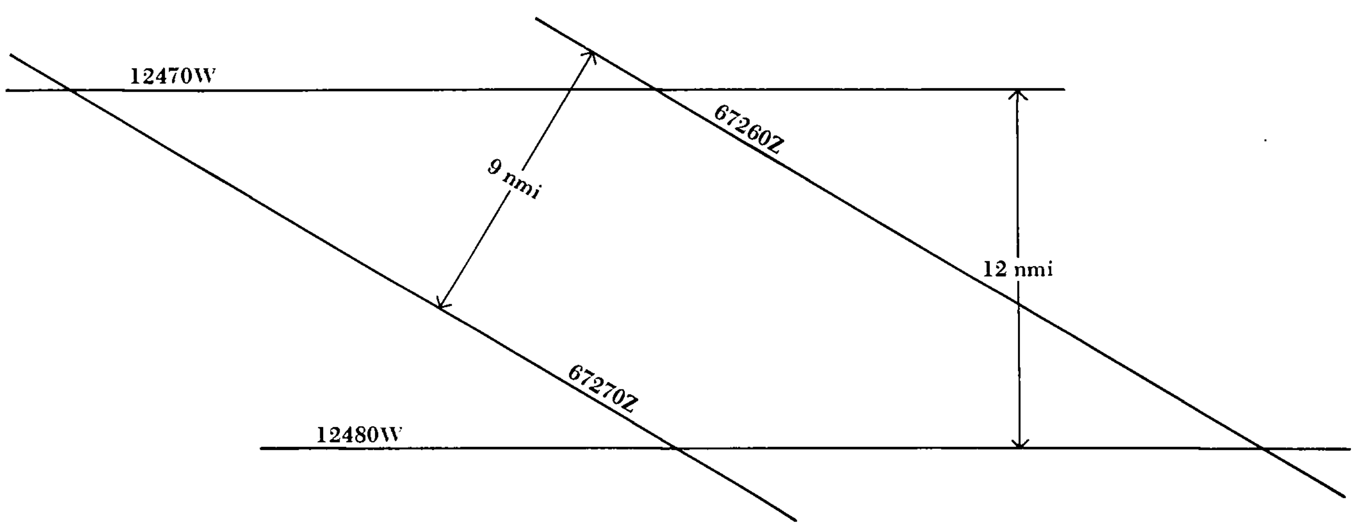


Figure 1 (1a, above; 1b, below).—*Loran-C gradients and crossing angles*



Using your receiver

A number of different types of Loran-C receivers are available. Each of them has different operator controls, and the steps the operator must perform vary with type of receiver. The best overall rule is to become well acquainted with the manufacturer's operation manual for your receiver. The following sections are general in nature rather than directed at any specific receiver.

Setting notch filters. Most receivers employ notch filters to eliminate electronic interference close to the Loran-C frequency band produced by communications or navigation stations. Some receivers have internal notch filters that are set at the factory or by the dealer. Other receivers have tunable notch filters that you can set. Generally, a receiver with tunable notch filters will have an indicator (a meter or a series of lights) to allow you to identify the interfering signal.

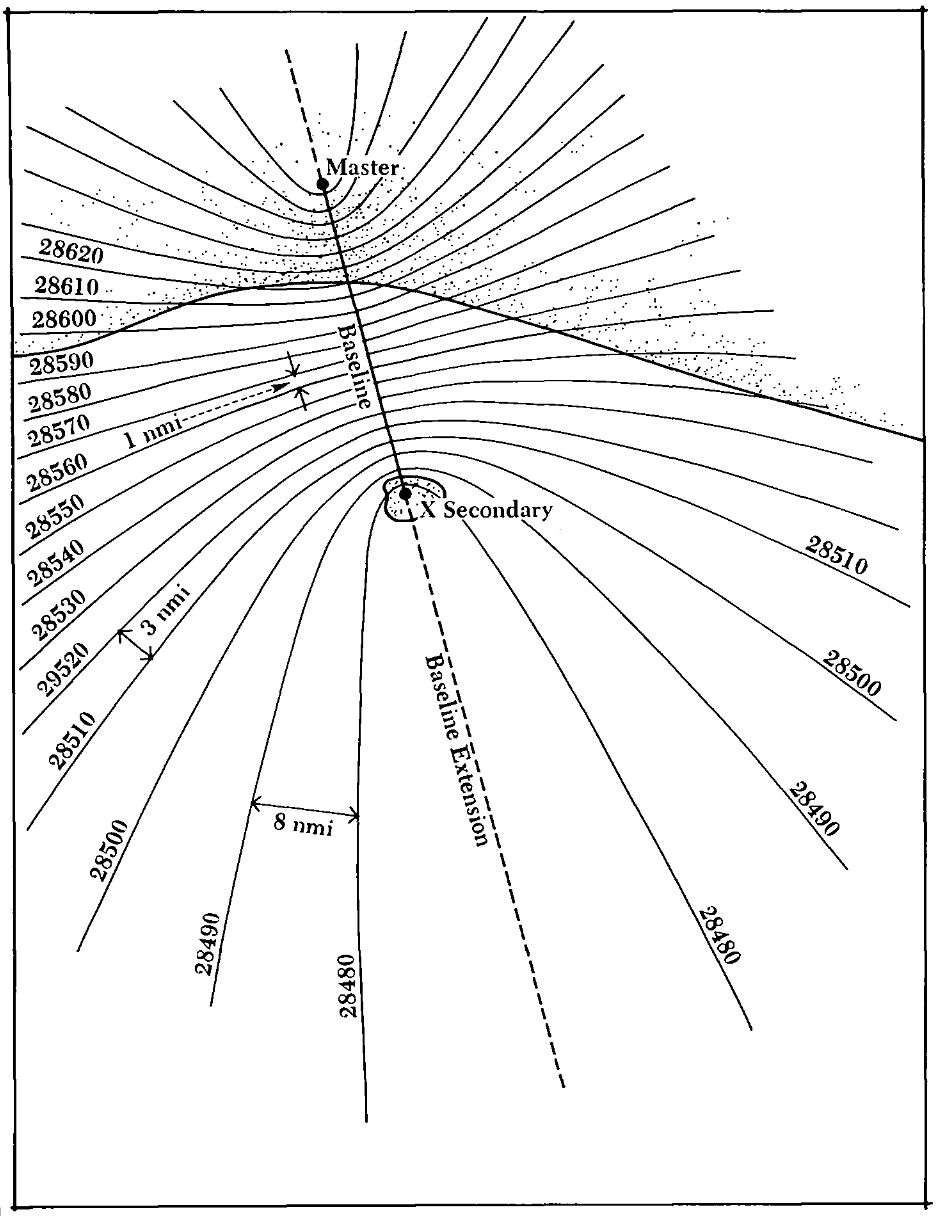


Figure 2.—*Baseline extension: Note large gradients near it*

You turn the tuning knob until the indicator displays maximum signal; then you use the notch-filter control to minimize the indicator reading. Where strong interference is present, it is important to use the notches. *Never set the notches in the center of the Loran-C signal,* or you will eliminate the Loran-C signal itself.

Normal operation. For the explanation of the various controls on your receiver, refer to the manufacturer's operation manual. In general, you operate a fully automatic Loran-C receiver as follows:

1. Turn receiver on.
2. Select the chain and secondary station for your area of interest.
3. Tune notch filters (it may be necessary to restart the receiver set if you had to use notch filters).
4. The receiver will then take over, acquire the signals, lock on the proper point on the Loran signal, and display the *time differences (TD's).*

Many receivers have a control that allows you to put the receiver in the track mode after it has locked onto the signal. This position may be labeled "Track," "Normal," "Freeze," etc. If your receiver has this control, use it. A receiver in the track mode is less susceptible to interference and will continue to track properly even when the Loran-C signal is not strong enough to lock on.

Operation in weak-signal or strong-noise areas. Until the Coast Guard completes reconfiguring Loran-C chains, Loran-C signals will be weak in some U.S. coastal waters. Also, a boat may be berthed in an area of high industrial noise that is impossible to eliminate with notch filters. If the Loran-C signals are very weak compared to the noise, your receiver may not be able to find the signals at all.

In many cases, however, your receiver can still operate in these areas, providing it has a cycle-step switch that allows you manually to increase or decrease the time-difference reading by 10-microsecond intervals. If you know what the time difference at your berth should be, increase or decrease the reading so that it displays the correct time difference. Then put the receiver in the track position.

Operation in fringe areas. When operating at the extremes of the Loran-C coverage area, you can assist the receiver in tracking. To do this (providing your receiver has the necessary controls), move the points at which your receiver is tracking the master and secondary signals higher on the pulse by using the cycle-step switch. The time differences do not change; the tracking point has been moved up equal amounts on both the master as well as on each of the secondaries. Some receivers in this condition will indicate a cycle error, but you may still use the reading.

One word of caution: When operating at the higher point on the pulse, the receiver operates on a stronger signal but is also susceptible to *sky-wave* interference. If your receiver tracks sky waves, you will obtain erroneous readings.

Recording actual time-difference readings. Normally, you will notice jitter, or jumping of the last digit of the readout, on your receiver. This will occur even though your boat is not moving, and is caused by noise interfering with the Loran-C signal. For this reason, when using the receiver for precise navigation, you should average your readings. Look at about six consecutive readings, mentally note the smallest and the largest, and then average these two to obtain the reading to be plotted or recorded.

Many receivers are fitted with a memory (or "Hold") switch. This switch locks the display with the present reading while the receiver continues to track internally. The memory switch can be most helpful in situations such as a crew member overboard. You should recognize, however, that the reading displayed may be 0.1 to 0.2 microsecond different from the average reading.

Alarms. Most receivers are fitted with one or more alarms. These are generally lights that, when extinguished, indicate that everything is normal. When lighted, they warn you that something may be wrong and that you should use the displayed time differences with caution.

Blink alarm. Abnormal conditions exist at one or more transmitting stations. Blink is a signal transmitted to warn you that the system may not be in tolerance. The receiver accepts this signal and visually indicates a warning.

Lost-signal alarm. The signal is too weak for the receiver to function properly.

Cycle alarm. The receiver is tracking the incorrect cycle on one or more signals so that the reading is incorrect by a multiple of 10 microseconds (such as 10, 20, or 30 microseconds). The cycle alarm may also come on when the receiver is in fact tracking the correct cycle but has not yet passed all internal tests necessary to verify that it is tracking the correct cycle.

Whenever an alarm light is on, use extreme caution. Do not use the time difference for navigation until the alarm light goes off.

Cycle selection problems. When you operate any navigation system *under high noise* or at the extreme limits of its range, it may not provide correct information. This is true of the Loran-C system where, under such conditions, the receiver may have difficulty in identifying the correct point at which to track the signal. Loran-C receivers in this condition may display a time difference which is either 10 microseconds too high or 10 microseconds too low. The only means of resolving the problem is manually to set the correct reading into the receiver (if you know it), using the cycle-step switch; then, if the receiver is so equipped, operate it in the track position. The cardinal rule of safe navigation is never to rely on a single system. Use a depth sounder and other aids *with* your Loran-C system.

Tips on plotting fixes. Loran-C is a highly accurate navigation system, and your receiver is a highly accurate measuring device; carelessness in plotting the fix can destroy this accuracy. A Loran-C receiver typically displays two time differences. These are a measure of the difference in time of arrival at the receiver between the master signal and the secondary signals you have selected. The grid of time differences is printed on the chart. In order to determine your position, you must take the time differences displayed on your receiver and plot them on the chart. Here are two methods of doing this (assume your Loran-C reading is 11347.5 microseconds):

Loran-C interpolator. On one corner of each Loran chart is a Loran interpolator (figure 3). Using a pair of dividers, measure off the distance on the chart between the lines 11340 and 11350. This distance is equivalent to 10 microseconds. Then place the dividers on the interpolator, exactly where one point rests on the top line and the other point on the bottom line. Without moving the bottom point, bring the top point straight down to a position 7.5 divisions from the bottom point. (It may help to temporarily pencil in 10, 8, 6, 4, and 2 over the numbers 25, 20, 15, 10, and 5 at the left.)

Now go back to the chart. Place the bottom point on the 11340 line; the top point indicates 11347.5. Draw a line

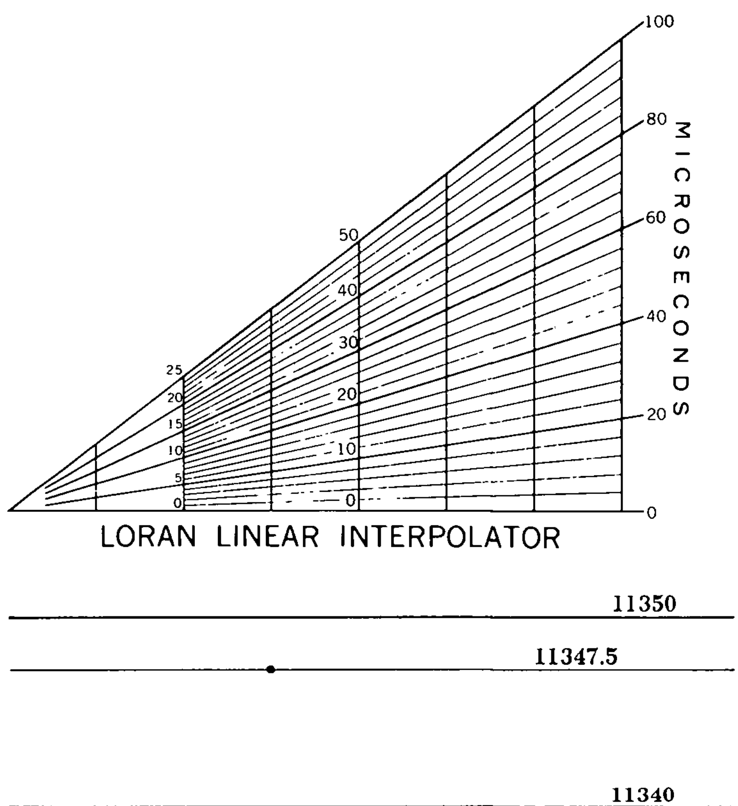


Figure 3.—*Use of Loran interpolator*

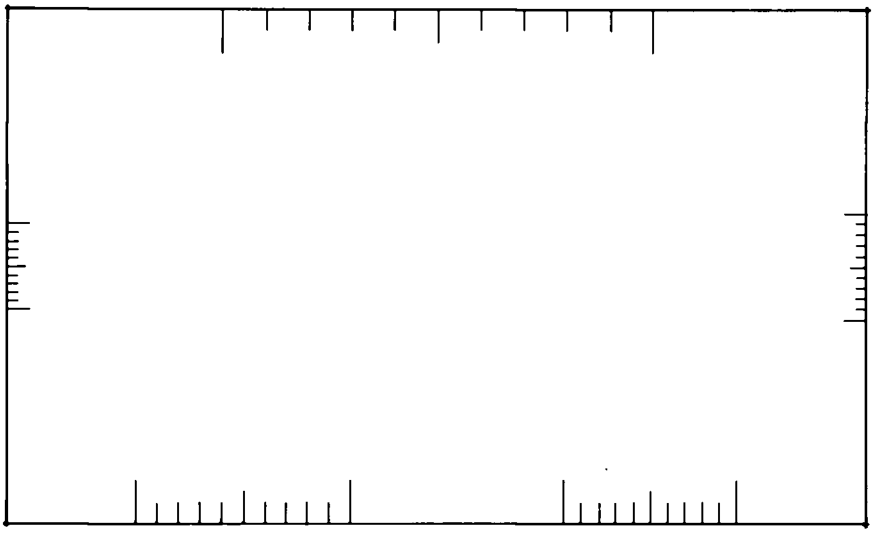
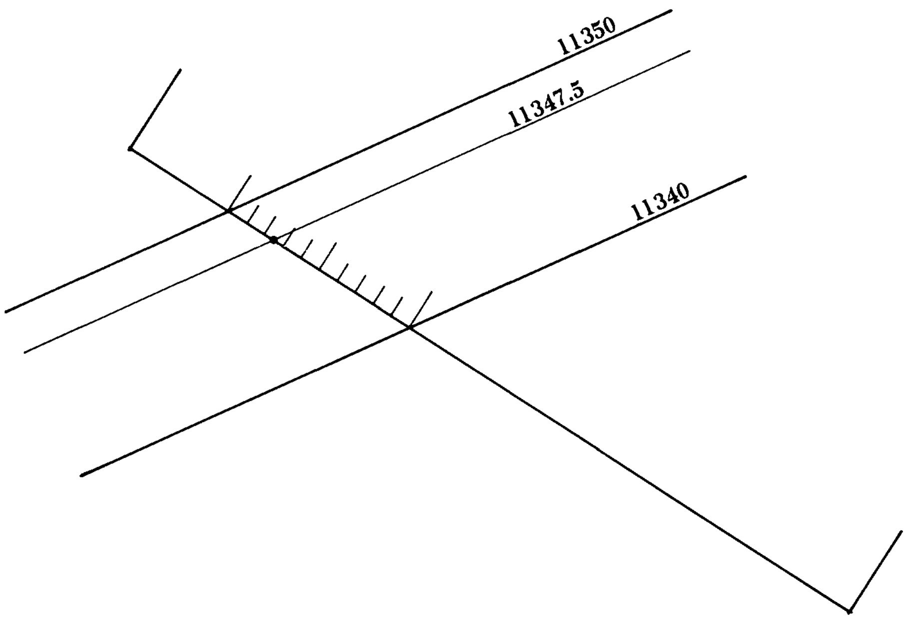


Figure 4 (4a, above; 4b, below).—*Use of homemade plotting device*



parallel to the printed lines and through this point. You have now plotted the 11347.5 LOP.

Homemade plotting device. Figure 4 shows a plotting device you can easily make from an index card. Note (figure 4a) that, although the scales are of different sizes, each has 10 equal divisions. To use this device (figure 4b), place the card so that the outer lines on the most convenient scale fall on the printed 11340 and 11350 Loran lines. To achieve this coincidence, you will probably have to tilt the card at an angle away from the perpendicular. You have now divided the distance between the two lines into 10 equal parts. Count up seven and one-half of these increments from the 11340 line and put a pencil point on the chart. Now rotate the card so that it is parallel to the printed Loran lines on the chart, and draw a line through the pencil point. You have plotted your 11347.5 LOP.

To determine your position, follow the same procedure for a second time difference. Your location is where the two plotted lines of position intersect.

Charts

Nautical charts are an integral part of the Loran-C system. As Loran-C service expands, the Government prepares charts to support the newly covered areas. For your planning purposes, if a particular chart was available with Loran-A lines, you can expect a Loran-C version of the same chart.

The agency that prepares charts for U.S. waters is the National Ocean Survey. You may obtain nautical chart catalogs at no charge from your local chart dealer or from Distribution Division (C-44), National Ocean Survey, Riverdale, Maryland 20840, telephone 301/436-6990. The catalogs show which charts are available by area and whether or not a particular chart includes Loran-C lines. The National Ocean Survey issues four regional chart catalogs: No. 1, *Atlantic and Gulf Coasts, including Puerto Rico and Virgin Islands;* No. 2, *Pacific Coast, including Hawaii, Guam, and Samoa Islands;* No. 3, *Alaska, including Aleutian Islands;* No. 4, *Great Lakes and Adjacent Waterways.*

In the same manner, you may obtain charts from your local dealer or by mail from Distribution Division (C-44), National Ocean Survey, Riverdale, Maryland 20840.

There are two other charting agencies you may be interested in: Defense Mapping Agency (DMA) and Canadian Hydrographic Service. DMA handles Loran-C charts for areas outside U.S. coastal waters (Mexican waters, for instance). DMA issues the *Catalog of Nautical Charts* (Pub. No. 1-N-A), available at no charge from DMA Topographic Center (Attn: DDCP), 6500 Brookes Lane, Washington, D.C. 20315. This catalog indicates the general variety of different navigational products that DMA handles, as well as listing the eight detailed area chart catalogs of the world that are available at nominal charge (currently $0.25 each).

Canadian Hydrographic Service issues Loran-C charts for both East and West Coasts of Canada. There are two regional chart catalogs of Canadian coastal waters. They are available at no charge from Hydrographic Chart Distribution Office, Canadian Hydrographic Service, Department of Fisheries and the Environment, Ottawa, Ontario K1A 0E6, Canada. Ask for *Atlantic Coast* or *Pacific Coast.*

A few cautions on charts. In order to have Loran-C charts available by the time Loran-C service starts in a particular area, the National Ocean Survey bases its first edition of Loran-C charts on predicted coverage rather than actual field measurements. In almost all cases, these predictions are quite accurate. In a few instances, however, there are unacceptably large errors. To find out about problems like this, read *Local Notice to Mariners* (and for how to subscribe to this no-cost publication, see "For more information"). Loran-C coverage for subsequent chart editions will be verified by actual measurements, but it is always prudent to check *Local Notice to Mariners* regularly to find out about unexpected problems and navigational changes.

Another aspect of charting that you should be aware of deals with secondary phase factor, a technical term for the way a Loran-C signal is affected by the land and water features over which it travels. Initial Loran-C computations are based on an ideal situation, in which the signal is assumed to travel over an all-seawater path. Loran-C signals, like all radio signals, however, are affected by the terrain over which they travel. Each kind of terrain—mountains, desert, snow, lakes, farm land—affects signals differently. In the case of Loran-C, many transmitting stations are located inland, so the signals you receive will usually have passed over land for a portion of their route to you.

This land effect, known as *additional secondary phase factor*, causes the Loran-C time-difference readings you see to differ from the readings you would obtain if the signals travelled across an all-seawater path. Additional secondary phase factors can be calculated and measured, and their effect is taken into account when making charts. At present, however, the Government makes only a single adjustment for additional secondary phase factor for each set of Loran-C lines on a particular chart.

Since additional secondary phase factors can vary from place to place, there may be locations on the chart where there are differences, usually minor, between the actual additional secondary phase factor and the average value which was used for making the chart. In such a case there would thus be a larger difference between the Loran-C readings you measure and the location on the chart where these readings would plot. It is expected that, when necessary, future chart editions will remedy this situation by using varying values for additional secondary phase factors on a chart, rather than just a single value.

Loran-C versions of large-scale charts for most confined areas (harbor approaches, harbors, sounds) are not now available. They will probably not be printed for several years. In the meantime, if you need Loran-C coverage on a large-scale chart, you can make your own. First, you need actual Loran-C readings at a point included on the chart, the *true* location of which you know *very* accurately by some other means such as visual observation. This location then becomes your local reference, or calibration, point. You plot the point on your chart and lay out the Loran-C lines from it. You can obtain the compass direction and spacing for Loran-C lines from a small-scale Loran-C chart, like a coastal or offshore chart, that includes the area in which you are interested.

A more accurate way to determine the direction and spacing for Loran-C lines, however, is to use the Loran-C tables published by Defense Mapping Agency. For information on their availability, consult the DMA *Catalog of Nautical Charts*, referred to earlier in this section. If you do make your own Loran-C chart, work carefully and check out the chart by taking actual Loran-C readings at a number of known locations before you depend on the Loran-C lines you have plotted.

Coordinate conversion

If you have operated with Loran-A, you may well have readings (on charts or in logbooks) that you want to switch over to Loran-C. You may have just a few readings such as the coordinates of sea buoys. Or you may have many, especially if you fish commercially, with extensive "hang" readings on bottom obstructions and logbook records of productive fishing areas.

How do you convert Loran-A readings to Loran-C? You have three choices, each with advantages and disadvantages.

The most accurate way of converting Loran readings is by **direct observation**: You equip your vessel with both Loran-A and Loran-C receivers and visit each location for which you want to convert Loran readings; once you reach the desired Loran-A position, read off and record the corresponding Loran-C readings. This method requires that both Loran-A and Loran-C systems be operating in your area.

Offering an opportunity for this method of coordinate conversion is one reason that the Coast Guard is providing 2 years of overlapping Loran-A and Loran-C service in each area. Direct observation is the most accurate method of coordinate conversion. It also is slow; it may require that you purchase a Loran-C receiver earlier than you want to; and it is expensive in terms of your and your vessel's time.

Another method uses **charts**. You plot the Loran-A position of interest and then read off and record the Loran-C coordinates. This is relatively simple if you have a chart where Loran-A and Loran-C lines are printed on the same side of the chart. With a number of Loran charts, however, a Loran-A chart is printed on one side and the Loran-C lines are printed on the other. In such a case, you must plot each Loran-A reading, carefully transfer the corresponding latitude and longitude to the Loran-C side, using dividers and parallel rules, and then read off the Loran-C reading.

The advantages of the chart method are that you can convert readings any time, and you avoid the expense of taking your vessel to each location. Disadvantages are: The process is slow and tedious; your conversion will be less accurate than direct observation (because of the factors discussed in the section on charts); you will probably not be able to convert the position if you determine it by one Loran-A reading and a sounding; and you cannot read the charted Loran-C coordinates on many charts more accurately than about 0.5 microsecond. If you need only an approximate conversion, the chart method may be adequate for you.

The final conversion method uses **calculators or computers**. This method is still experimental, but it offers considerable promise. It requires writing a program for the particular calculator or computer you will use. You then enter two Loran-A readings, and the calculator or computer calculates the corresponding two Loran-C readings. This method is very fast (almost instantaneous) on a desk-top computer but quite slow (about 3 minutes per conversion) on a handheld, programmable calculator. The advantages of this method, as with the chart method are that you can convert readings any time, and you avoid the expense of taking your vessel to each location. The computer method can be highly accurate, but its accuracy depends on the use of local calibration points for which Loran-A coordinates, Loran-C coordinates, and true position have been simultaneously determined. Disadvantages are: You must have two Loran-A readings for each point you wish to convert, and you must have access to a computer or a programmable calculator for which a program has been written.

Accessories

A number of accessories are available for use with your Loran-C receiver. These devices may be valuable to you, depending upon your needs and method of operation.

Remote readout. A number of manufacturers offer this unit, which is desirable if the time differences are required in a location that is open to the weather, or if there is not room to mount the receiver in the wheelhouse. The remote readout usually displays two time differences and has an alarm light and memory switch. Once a remote unit is installed, you can use it in the crew-member-overboard situation, or in computing set and drift. Putting the remote in memory while observing the TD's on the receiver itself has proved effective in both these instances.

Latitude-longitude converters. Some manufacturers offer latitude-longitude converters as an integral feature of their receivers while others offer a remote converter as an accessory. In either case, the readout is in latitude-longitude. You no longer need to plot time differences; you can plot your position directly in latitude-longitude. Caution: Generally, the latitude-longitude readout is based upon equations that compute the position based on an all-seawater path between the receiver and the transmitters. Since the computation does not apply an additional secondary phase factor correction, the position is not as accurate as you would expect in plotting your time differences directly on the chart.

At least two manufacturers offer **track plotters.** These are horizontally mounted units in which you insert a chart or sheet of plain paper. The plotter is connected to the receiver, and the pen movement is related to the change in Loran time differences. The accuracy obtainable with a track plotter depends upon the scale that you use. Some examples of effective use of a track plotter are:

1. Track plotters can be useful when conducting a search. They show the vessel track corrected for wind and current. Track spacing can be set up in advance.
2. Track plotters are also particularly effective on vessels that repeatedly transit the same area. Skippers of vessels such as ferries can ink in the normal lanes on a chart. They would start the plotter pen at the terminal and navigate the vessel within the lanes using the plotter pen (with or without ink).
3. Another use of track plotters is to enable you to keep a permanent record of your vessel's movements. For passing back and forth over scallop beds, you would start the pen on a sheet of paper, noting the TD's and the date. You would record your track on this occasion. At any future time, you could run the same track by proceeding to the noted TD's and starting the pen here once again. You then steer your boat to follow the recorded track. You could use this record over and over from year to year; the Loran-C grid is extremely stable over time.
4. Track plotters can also provide a record similar to logbooks. At present you must manually record readings, such as the locations of crab pots, in a logbook. By contrast, a track plotter provides a convenient and permanent record of where you have been.

Putting it all together

To summarize all these pointers and recommendations, imagine you are taking a trip on the *Ground Wave*, a wood-hull crab boat out of Newport, Oregon. The owner has just purchased a Loran-C receiver and has had the local marine electronics dealer install it. The antenna is installed on top of the mast with a ground strap that runs down the wooden mast from the coupler to the receiver. The receiver is grounded to the engine block. The boat had high internal noise, so it was necessary to bond the ignition coil to the block and shield the leads to the electronic tachometer. Fortunately, it was raining the day the receiver was installed. The windshield wiper motor interfered with the Loran-C receiver, so a filter was put on the motor leads.

Hi Perbola, owner and skipper of *Ground Wave*, was very attentive when the dealer, Loren Sea, explained how to operate his new receiver. He even wrote down the time differences (TD's) obtained at the dock when Loren finished the installation last night. (It was late and all of the welding shops near his berth had closed down for the night.)

Now Hi is ready to get underway. He turns the receiver on and selects the preferred chain for his planned trip. It will only be a 1-day trip, and he is using the chain and secondaries that are best for his area. He tunes the notch-filter tuning control through its range and detects a large signal off to the right of center. Using the tuning control, he peaks this signal on the meter.

Going to the right-hand notch-filter control, he minimizes the meter reading. He notes that the meter seems to read higher across the entire band than it did last night (all those welding machines are now in operation), but he cannot find a sharp peak indicating other interfering signals. He turns the left notch-filter all the way counterclockwise to insure that he does not notch out the Loran-C signal. As long as Hi operates in the same area and conditions do not change, he does not need to set notch filters each day.

Hi then makes his other preparations for getting underway. He returns a few minutes later to see that all warning lights on his receiver are *off*. He notes, however, that both of the time differences are reading 10 microseconds less than last night. Hi concludes that, because of the industrial noise nearby, his receiver has locked onto the master signal 10 microseconds too high. He jumps the receiver down 10 microseconds on the master and puts it in the track position. (If only *one* of the TD's had been different, he would have jumped only that secondary.) The TD's now are identical with last night's readings; they also are very close to the readings for his berth as shown on the chart.

Ground Wave gets underway. Hi has a hand-drawn chart of the harbor that Loren provided and on which the Loran lines from a small-scale chart of the area have been extended. The chart has also been calibrated by using observed time differences at landmarks. Hi is aware that he is not getting the full accuracy of the Loran-C system since the TD lines on the homemade chart are drawn as straight rather than hyperbolic (curved) lines. As *Ground Wave* proceeds out of the channel, visibility is excellent, and Hi writes down on his chart the time differences as he passes each of the buoys.

When *Ground Wave* departs the sea buoy, Hi switches to the small-scale chart with the TD's printed on it. By carefully plotting his position, he now can expect an absolute accuracy within ¼ nautical mile. However, accurate navigation at this point is not critical, and

Hi notices that the X secondary lines run in a northwesterly direction toward his favorite crabbing spot. The receiver has been mounted so that the readout can be seen from the wheel. He tells deckhand Sam Pling to steer in a northwesterly direction and maintain a constant time difference on the X readout. Hi will determine their progress by observing the crossing W time differences.

When they arrive at the crabbing area and Sam is setting the crab pots, Hi carefully averages the Loran readings for each pot location. He records these on the chart.

Meanwhile, weather has deteriorated and heavy fog has set in. Visibility is on the order of 30 meters (100 feet). *Ground Wave* now proceeds to another area. Sam is aft making up the crab pots. Hi hears a yell; as he turns, he sees that Sam is no longer on board. He immediately punches the memory button on the receiver. While making his turn, he writes down time differences, then punches the memory button again, returning the receiver display to normal operation. He maneuvers the boat so that the displayed time-difference readings are the same as those he recorded. With the boat at a low speed, Hi hears Sam yelling and helps him aboard.

While Sam is changing to dry clothes, he throws his wet shirt over a frayed electrical wire, causing the circuit breaker to trip and the boat to lose all electrical power. Once power is restored, Hi restarts his receiver, making sure that he has taken it out of the track position. After the receiver locks on and all warning lights are off, he returns it to the track position.

They drop off another set of pots, again recording the time differences, and then proceed back to check the first set of pots. In the thick fog, Hi relies on his Loran-C readings and his depth sounder. He now is using Loran-C in the repeatable mode and can expect an accuracy on the order of 30 to 60 meters (100 to 200 feet) in this area. He maneuvers the boat to the correct W secondary TD. Hi then steers to keep the W reading constant while the X secondary TD increases (or decreases) to the correct value as he approaches his previous position. They retrieve the pots and head *Ground Wave* for home.

Hi steers the reverse of his outbound course, using the same constant X secondary as a reference. He finds the sea buoy easily since he had recorded its time differences on the way out. He makes his way up the channel, from buoy to buoy, using the previously recorded TD's. Sam assists by observing the depth sounder to insure that they remain in the channel.

As they tie up at their berth, Hi checks the time differences to make sure they are identical with his morning readings. He still has pots out and wants to satisfy himself that his receiver did not malfunction when the power failed. The time differences read the same, so Hi has confirmed that he has the correct time differences for his pots.

During their discussion after they had tied up, Sam Pling points out that although their catch for the day did not amount to much, the trip was a valuable experience in learning how to operate the new Loran-C receiver.

Glossary of terms

Absolute accuracy—A measure of your ability to determine true geographic position (latitude and longitude) from a navigation system such as Loran.

Additional secondary phase factor—The amount in microseconds by which the time difference of an actual Loran signal that has traveled over varied terrain differs from that of an ideal signal that has been predicted on the basis of travel over an all-seawater path.

Baseline—The great circle line connecting the master transmitting station and a secondary transmitting station. You can obtain the most accurate Loran readings on or close to the baseline.

Baseline extension—The extension of the baseline beyond either the master or secondary transmitting station. Do not use Loran readings in the vicinity of the baseline extension, because of low accuracy as well as the difficulty you have in knowing which side of the baseline extension you are on.

Chain—A Loran-C network consisting of a master transmitting station and two to four secondary transmitting stations.

Fix—Determination of your navigational position, using two or more lines of position.

Gradient—A measure of the spacing between adjacent Loran lines. As with all hyperbolic navigation systems, the Loran gradient varies, depending on your location with respect to transmitting stations. If you are in a location where the gradient is large, small changes in time difference correspond to large changes in your indicated position.

Ground wave—A radio wave that travels near or along the Earth's surface.

Line of position (LOP)—A line on which you are located, as determined by a single navigational observation. This line represents the series of locations of constant Loran-C time difference. The intersection of two or more LOP's results in a fix.

Master—The governing station in a Loran-C chain.

Microsecond—One-millionth of a second, referred to as a *mike* in common marine language.

Notch filters—Filters in the receiver that are either fixed or capable of being tuned to reduce the effects of interfering signals.

Repeatable accuracy—A measure of your ability, through using a navigation system such as Loran, to return to a position where you have been before.

Secondary—General designation of the two to four subordinate transmitting stations in a Loran-C chain. The secondary stations transmit in sequence after the master at fixed, predetermined intervals.

Signal-to-noise ratio (SNR)—The ratio of the Loran-C signal level to the level of background noise. Most Loran-C receivers are designed to operate with an SNR of 1:3 or stronger.

Sky wave—An indirect radio wave that reflects off the ionosphere, rather than traveling a direct path from transmitter to receiver.

Time difference (TD)—The difference in time of arrival (measured in microseconds) of two Loran signals, one from the master transmitting station and the other from one of the secondaries.

For more information

On the principles of Loran

Consult any good basic text on navigation. Two of the best are: *American Practical Navigator* ("Bowditch"; Washington: U.S. Government Printing Office, 1962 or later edition) and Elbert S. Maloney, *Dutton's Navigation and Piloting* (Annapolis: U.S. Naval Institute, 1978).

On Loran-C

Loran-C User Handbook, U.S. Coast Guard Publication CG-462 (Washington: U.S. Government Printing Office, 1974), available from Coast Guard District Offices.

On Loran-C receivers

D. A. Panshin, *What You Should Know About Loran-C Receivers*, Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 50 (Corvallis, 1978).

Wild Goose Association Radionavigation Journal 1977, Wild Goose Association, 4 Townsend Road, Acton, Mass., 1977.

On the economics of Loran-C

F. J. Smith, *Financial Considerations in Switching from Loran-A to Loran-C* and *Loran-C Receivers: Making the Decision*, Oregon State University Extension Service, Sea Grant Marine Advisory Program Publications SG 56 (in press) and SG 47 (Corvallis, 1979).

On installation

D. Smoler, "Loran-C Installation," *NMEA News*, Jan.-Feb. 1978, pp. 26-27, 58-59 (National Marine Electronics Association, 49 Delwood Lane, Tinton Falls, New Jersey 07724).

On the causes and cures of noise

J. Honey, *The Noise Book* (2nd ed., 1976), Marine Technology, 2780 Temple Avenue, Long Beach, Cal. 90806.

Brand-name sets are shown in this bulletin as examples only; their depiction does not constitute an endorsement of these sets.

Coast Guard District Offices

If you have questions on Loran-C, write or phone the Chief, Electronics Engineering Branch, at the district office closest to you, or:

Project Officer
Loran-C Education and Information Project
U.S. Coast Guard Headquarters (G-WAN/73)
400-7th St., S.W.
Washington, D.C. 20590
Tel. 202/426-0990

Note that the phone number listed for each district office below is for the Chief, Electronics Branch, *only*.

If you wish to receive *Local Notice to Mariners*, write to the Chief, Aids to Navigation Branch, at the closest district office.

First Coast Guard District
150 Causeway St.
Boston, MA 02114
Tel. 617/223-3670

Second Coast Guard District
1430 Olive St.
St. Louis, MO 63103
Tel. 314/425-4637

Third Coast Guard District
Governor's Island
New York, NY 10004
Tel. 212/264-3708

Fifth Coast Guard District
Federal Office Bldg.
431 Crawford St.
Portsmouth, VA 23705
Tel. 804/398-9267

Seventh Coast Guard District
1018 Federal Bldg.
51 SW 1st Ave.
Miami, FL 33130
Tel. 305/350-5674

Eighth Coast Guard District
Hale Boggs Federal Bldg.
500 Camp St.
New Orleans, LA 70130
Tel. 504/589-6277

Ninth Coast Guard District
1340 East 9th St.
Cleveland, OH 44199
Tel. 216/522-3960

Eleventh Coast Guard District
Union Bank Bldg.
400 Oceangate Blvd.
Long Beach, CA 90802
Tel. 213/590-9249

Twelfth Coast Guard District
630 Sansome St.
San Francisco, CA 94126
Tel. 415/556-6512

Thirteenth Coast Guard District
915 Second Ave.
Seattle, WA 98174
Tel. 206/442-5845

Fourteenth Coast Guard District
300 Ala Moana Blvd.
Honolulu, HI 96850
Tel. 808/546-5539

Seventeenth Coast Guard District
P.O. Box 3-5000
Juneau, AK 99801
Tel. 907/586-7327

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OREGON STATE UNIVERSITY
EXTENSION SERVICE

Extension Service, Oregon State University, Corvallis, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Extension's Marine Advisory Program is supported in part by the Sea Grant Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

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