

## THE OFFSHORE DRIFT OF LARVAE OF THE CALIFORNIA SPINY LOBSTER *PANULIRUS INTERRUPTUS*<sup>1</sup>

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The information that I have to offer regarding the drift of the larvae of the California spiny lobster *Panulirus interruptus* (Randall) will perhaps not contribute much directly toward indicating the relative strength of the northward components of water flowing along our coast during the past year. It will, however, point up some interesting questions regarding water currents and recruitment of lobster stock. I will be able to show you in a way that has not been done before, what happens to a floating population of larvae originating near the coast of Southern and Baja California.

For the discussion to follow it is important to note that the adult *Panulirus interruptus* is reported to range from slightly north of Point Conception southward to Manzanillo, Mexico. From the present study it appears that the main centers of concentration are in the regions of the Channel Islands and of Cedros Island off Baja California.

For those of you who are not familiar with the life history of the spiny lobster, it should be said here that the adult female carries its eggs attached to the swimming feet. The larvae, which hatch from the eggs, are thoroughly transparent, flat and thin as a bit of paper, and are known as "phyllosoma." The first stage is about 1½ mm long and the last stage is about 30 to 32 mm long. Between each stage, of which there are eleven, there is a shedding of the old skin to allow for increased growth.

When released in the water, these larvae float about with prevailing currents like so many tiny drift bottles. The last phyllosoma stage metamorphoses into a "purulus" stage which, though still transparent, resembles the adult and soon seeks the bottom to assume the adult habit.

With this brief background we can now discuss in a summary way, when and where these larvae first appear in the plankton as Stage I, and when and where they are found in subsequent stages. A much more complete analysis will be published in the Bulletin, Scripps Institution of Oceanography, University of California, 1960. Here, it will suffice to give only a few typical examples selected from seven years of study based on the monthly plankton collections made by the California Cooperative Oceanic Fisheries Investigation. Involved are a great number of stations extending along the coast from above Cape Mendocino to well below Cape San Lucas, and seaward to distances up to 200 to 300 or more miles (Fig. 1). The collections were made with a one-meter net towed obliquely usually from 70-0 meters or 140-0 meters.

<sup>1</sup> Contribution from the Scripps Institution of Oceanography.

Figure 135 shows the periods of the year in which each of the phyllosoma stages I to XI were found during each year of the seven-year study period. The first stage occurs only from about mid-June to mid-November (once in early December). A line drawn through the mid-period of occurrence of the successive stages, indicates that the total larval life, Stages I to XI, requires about 7¾ months. Hence, for this long period the larvae are presumably drifted about at the mercy of prevailing water currents.

In a summary (Fig. 136) of many samples, it can be seen that the source of larvae is at the immediate coast or in the vicinity of islands. This is, of course, in keeping with the known distribution of the adults.

The later larval stages occur in diminishing numbers and usually at greater distances from the coast (Fig. 137). In general, there is a drift of larvae to the south and southwest. This is to be expected in view of the prevailing southward flow of the California Current.

Rarely are larvae found to the north of Point Conception. There is a notable exception shown in figure 138. A Stage X larva was caught in May 1954 about 200 miles at sea in the latitude of Monterey Bay. It is difficult to account for this specimen on the basis of the calculated prevailing currents. It was found in water characterized as Southern or Central Pacific by the presence of only one variety, (i.e. *californicus*) of the copepod *Eucalanus bungii*, in contrast to the inshore tongue of colder water where the northern variety *Eucalanus bungii bungii* constituted up to 28 percent of this species. There is also a record of a Stage I larva taken August 1954 near the coast just north of Monterey Bay in 14°C water in which only *Eucalanus bungii californicus* was found.

Evidence of flushing of larvae from a restricted area is shown in figures 139 and 140. The area around the Channel Islands was surveyed by a cruise, the second half of which immediately resampled the stations visited during the first half. During the first sampling 41 percent of the stations located inshore of the dashed line shown in the figures yielded Stage I larva, whereas none were found there during the second sampling.

Despite these instances of larval dispersal, it is amazing that when the whole area is considered, there is so little direct evidence of larvae being flushed wholesale from the area. Evidently there prevail along the coast countercurrents, long back swirls, and eddies that effectually retain a good number of larvae up through the later stages within or near the area of adult distribution even for so long a period as 7¾ months. The calculated dynamic anomalies, which

were here kindly provided by the Hydrographic Section, describe patterns of flow tending to support this view. The charts shown in figures 141 to 147 illustrate such back currents as are at times detected from hydrographic studies. Some of these charts also show sections as having currents which, if continuous for long periods, would flush all surface living larvae from the area.

Doubtless many, if not most, of the later stage larvae which we have caught at stations distant from the shore or south of the heavy dashed line shown in figures 136 and 137 are on their way out on currents that will sweep them into uninhabitable areas. What portion of the larval population this loss may represent we cannot estimate with any certainty without further extension of our collecting methods to include more sampling at or near the bottom in both shallow and deep water. For it is not entirely clear just what hydrographic mechanisms combined with larval behavior make possible a recruitment of lobsters sufficient to support the rather stable lobster fisheries that we enjoy.

## DISCUSSION

*Sette:* Dr. Johnson, I am going to ask the first question. Do you have some data on larvae for the last year or two?

*Johnson:* We have not sorted all of the 1957 material as yet but we have made certain spot tests to give some idea of what is taking place with regards to larval distribution in 1957. At least some significant data seem to be emerging. In the first place, the larvae appear not to have been swept in detectable numbers to the north of Point Conception, or if they are swept to the north they quickly succumb to changing conditions. But as shown in figure 147 for the July 1957 cruise, there is an unusually large number of early-stage larvae in the region of the Channel Islands. The number of Stage I larvae taken in that area was far above average for the area for past years, and furthermore these larvae were present in numbers greater than ever before during the month of July, which appears to indicate that hatching had begun about a month earlier than usual.

Another unexpected feature of this cruise is the almost complete absence of larvae from the collections south of Punta Eugenia as if there had been an intrusion of phyllosoma-free water from offshore. The dynamic height anomalies seem also to bear this out. It can also be said that more late stage larvae were taken between February and July than for that period in any previous year. Thus, while the data do not show more drift out of the area, there appears to have been some earlier hatching in the northern part of the range and probably a better survival to later stages or better retention, especially in the Baja California area.

*Isaacs:* Would you say that most of the population has shifted to the north?

*Johnson:* No, larvae are still abundant in the central Baja California area, but there might have been some shift northward from below Punta Eugenia during July. However, for other months, especially October 1957, this is not borne out.

*Berner:* Could the larger number of Stage I larvae in the Channel Islands area be explained by a water movement along the coast carrying larger numbers from the south into the Channel Islands area?

*Johnson:* Yes, this could be so, since the larvae apparently remain in Stage I for a matter of two to three weeks. However, the presence of so many as 76 larvae at one station argues against the idea that there had been much opportunity for dispersal prior to the catch. But still it is probable that the lobsters in that area are largely restocked by settlement of larvae that have drifted in from the south. The extent of adult migration into the area is not known.

*Radovich:* Regarding the possibility of the lobsters getting back to the Channel Islands area, I talked with a gentleman from the cannery at San Quentin who mentioned a rather interesting phenomenon. He had observed a school of full-sized, 12-16-inch lobsters swimming at the surface. He had never seen this before but in talking with other lobster fishermen in the area, they told him they had witnessed this phenomenon some few months before. One fisherman has used scoop nets to fill this boat with lobsters. This sounded peculiar to me and I mentioned it to Mr. W. L. Scofield at the California State Fisheries Laboratory. He said that about 20 years ago he interviewed a fisherman who had observed the same phenomenon.

*Johnson:* On the whole, I have considerable respect for observations made by fishermen, but sometimes they do make mistakes.

*Davies:* This is similar to a report from one of our South African lobster fishermen, who witnessed thousands of lobsters swimming all in one direction.

*Marr:* There is a record of marked spiny lobsters at Bermuda having been released offshore at the surface over deep water and fifty miles from the island. Subsequently, they were recovered at approximately the same place from which they were taken originally. The supposition was that they swam back instead of sinking.

*Johnson:* There have been tagging experiments on our local lobster which show some short migrations but mostly random movements so far as we know.

*Sette:* I suppose the question before us is whether or not the drift of larvae differed in 1957 from previous years. According to conclusions you have drawn from your charts, they drift with no swimming effort and should reflect changing conditions. We will look forward to a more complete story when more data have become available.

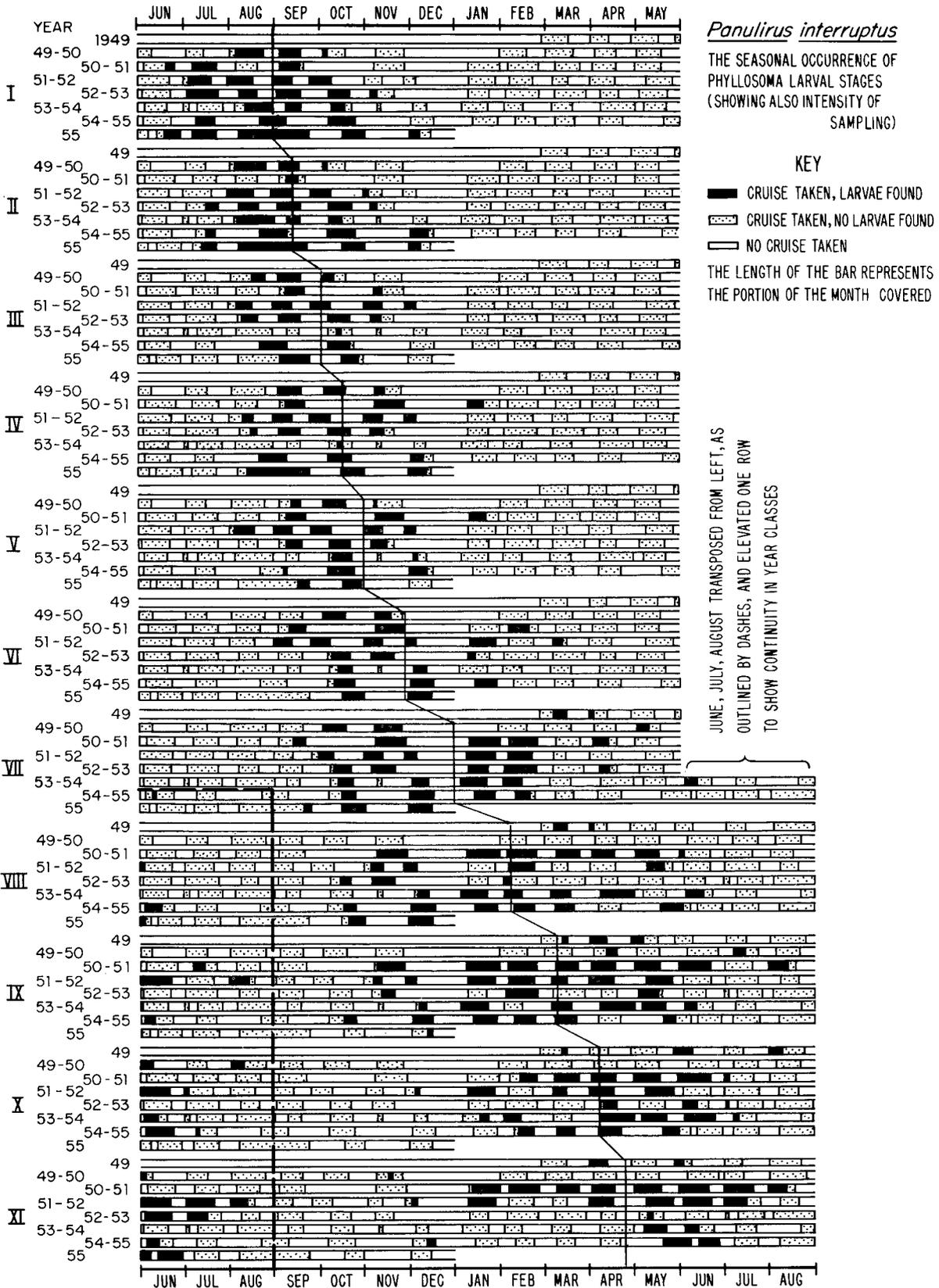


FIGURE 135. Seasonal occurrence and duration of larval stages of *Panulirus interruptus*, with indication of the intensity of sampling.



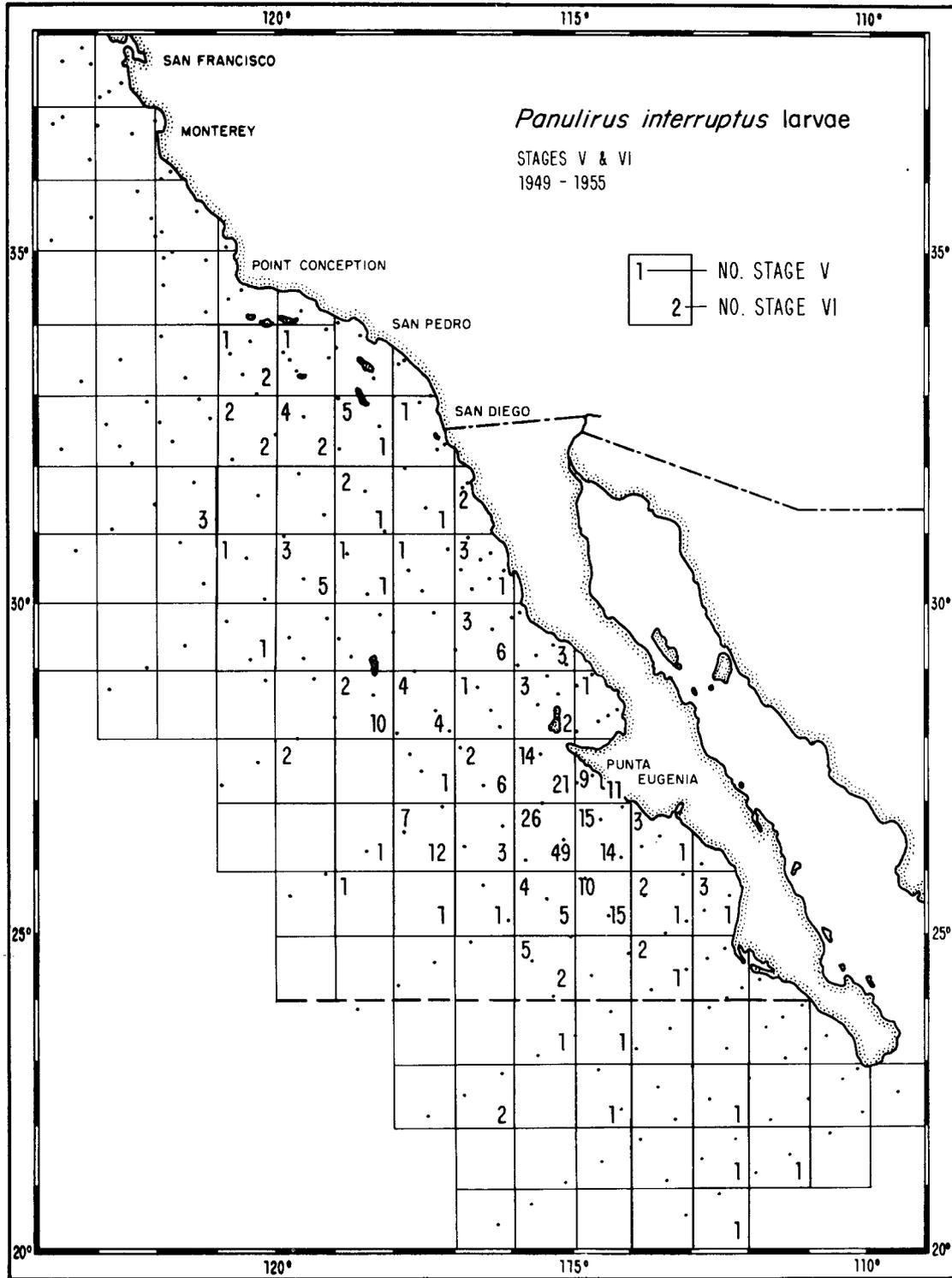


FIGURE 137. Summary of geographic distribution of Stages V and VI larvae of *Panulirus interruptus*, 1949-1955 inclusive. The numbers of larvae caught are shown for each one-degree square.

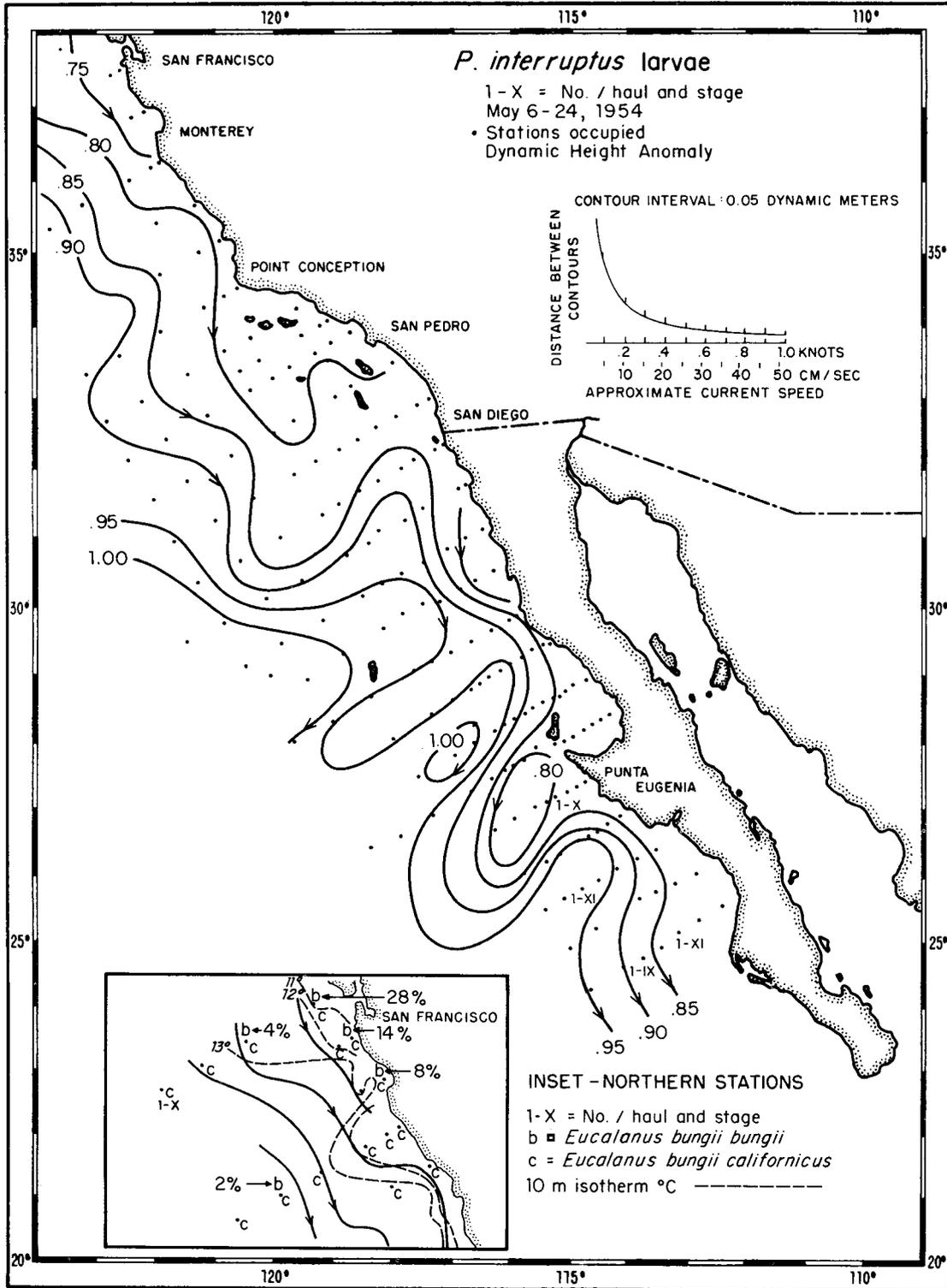


FIGURE 138. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 500 decibars) during May 6-24, 1954 (CCOFI Cruise 5405).

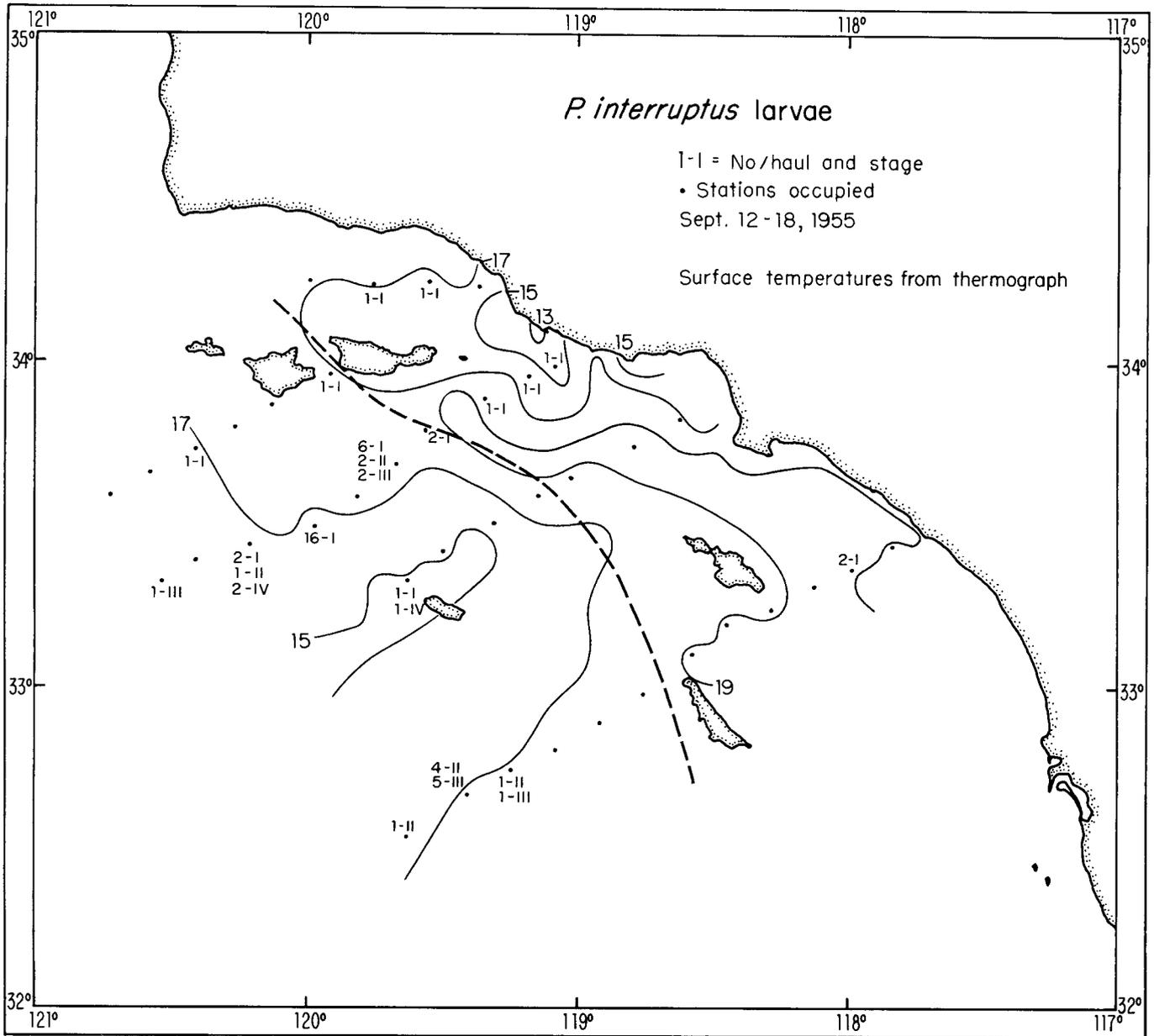


FIGURE 139. Locality records for *Panulirus interruptus* larvae and surface isotherms in the Channel Islands area during September 12-18, 1955 (CCOFI Cruise 5509). Inner and outer areas separated by dashed line.

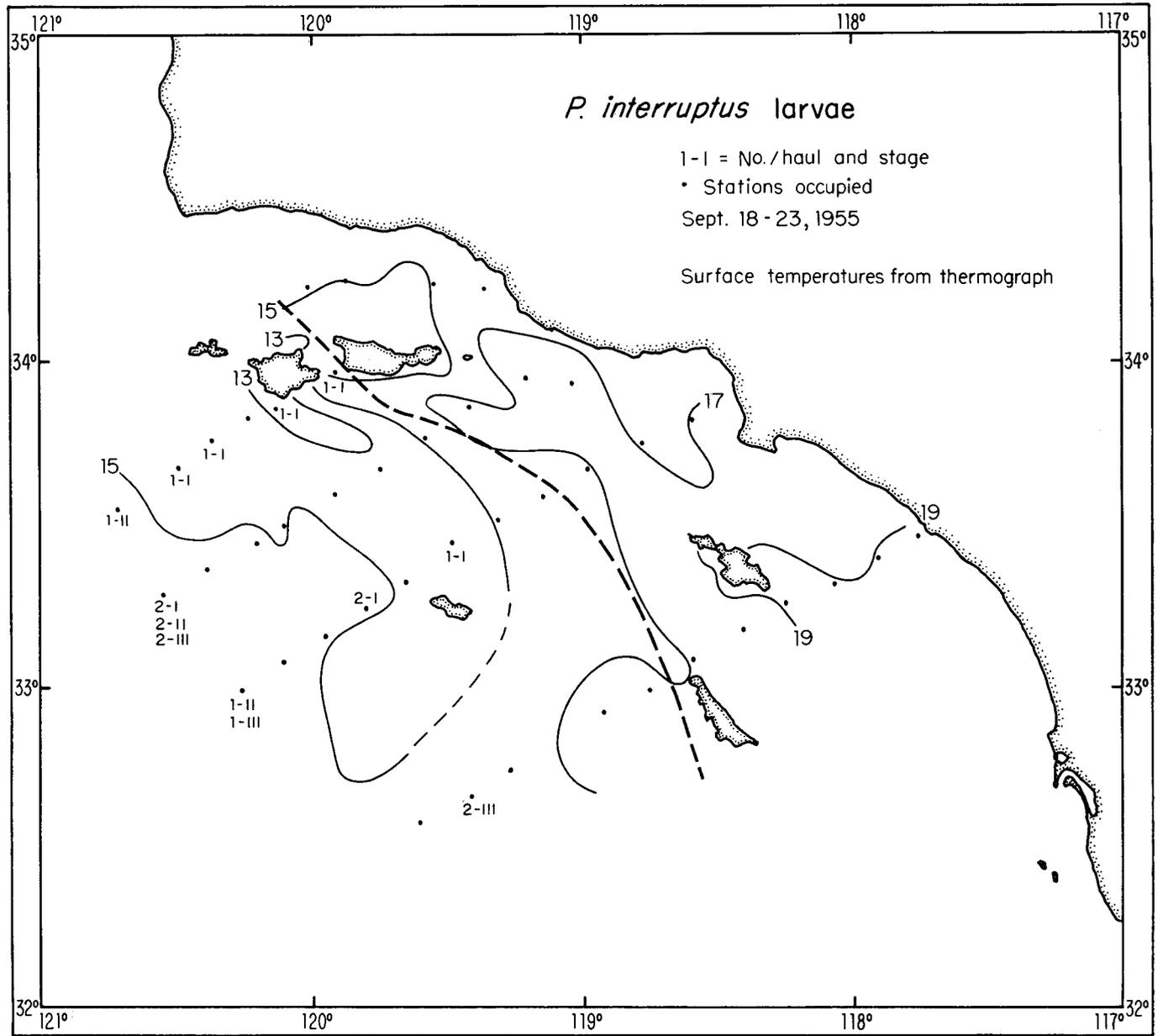


FIGURE 140. Locality records for *Panulirus interruptus* larvae and surface isotherms in the Channel Islands area during September 18-23, 1955 (CCOFI Cruise 5509).

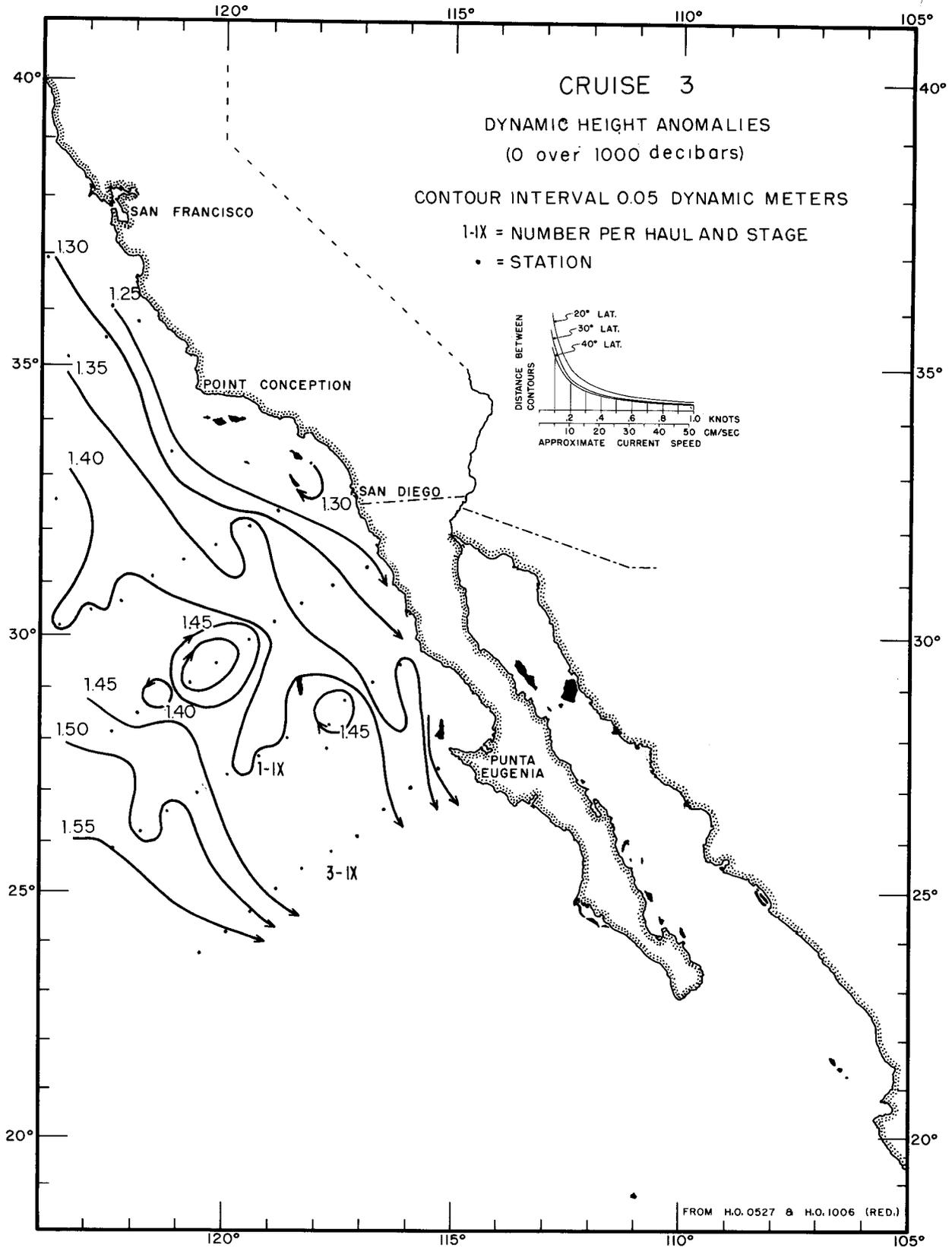


FIGURE 141. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during April 28 to May 14, 1949 (MLR Cruise 3).

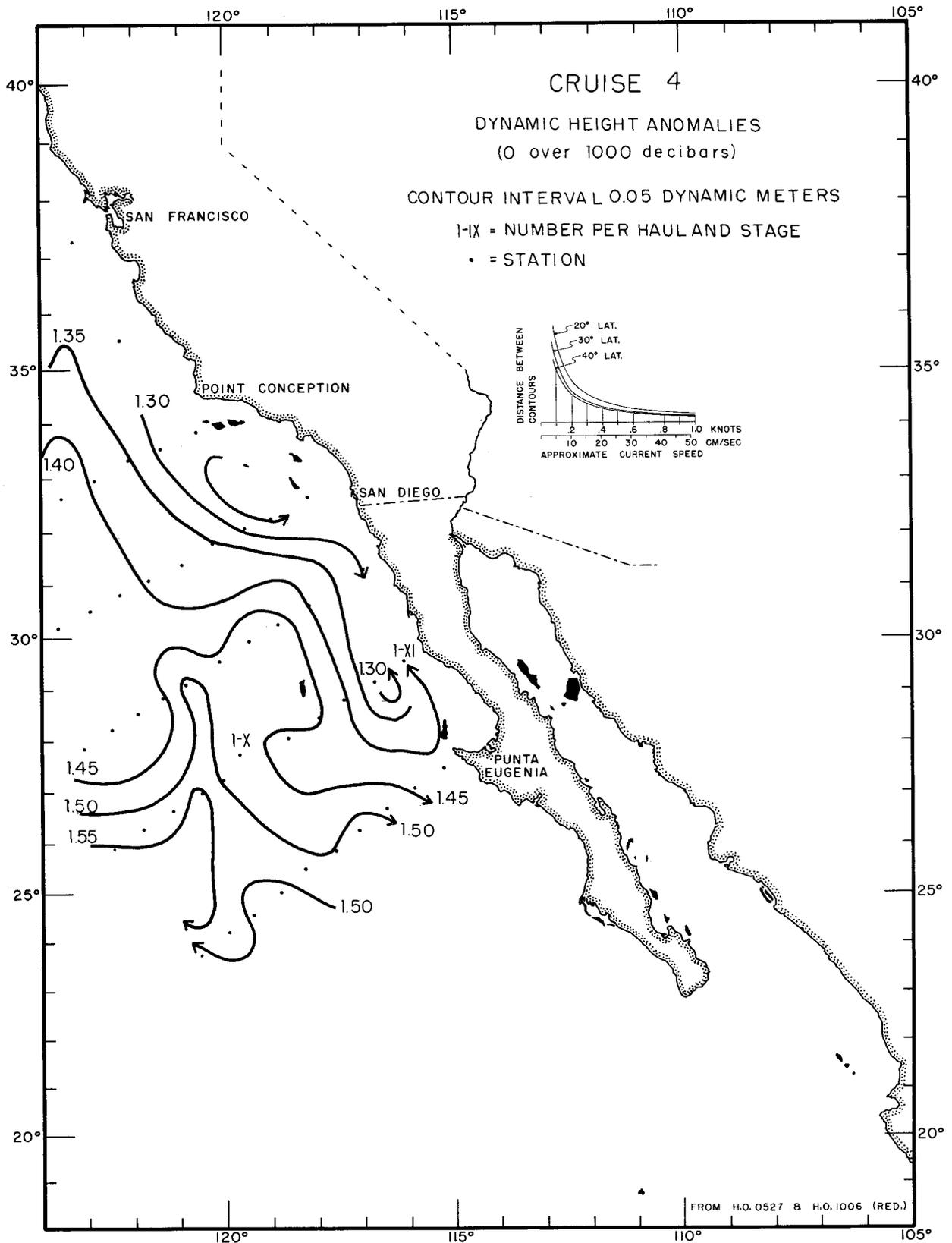


FIGURE 142. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during May 28 to June 9, 1949 (MLR Cruise 4).

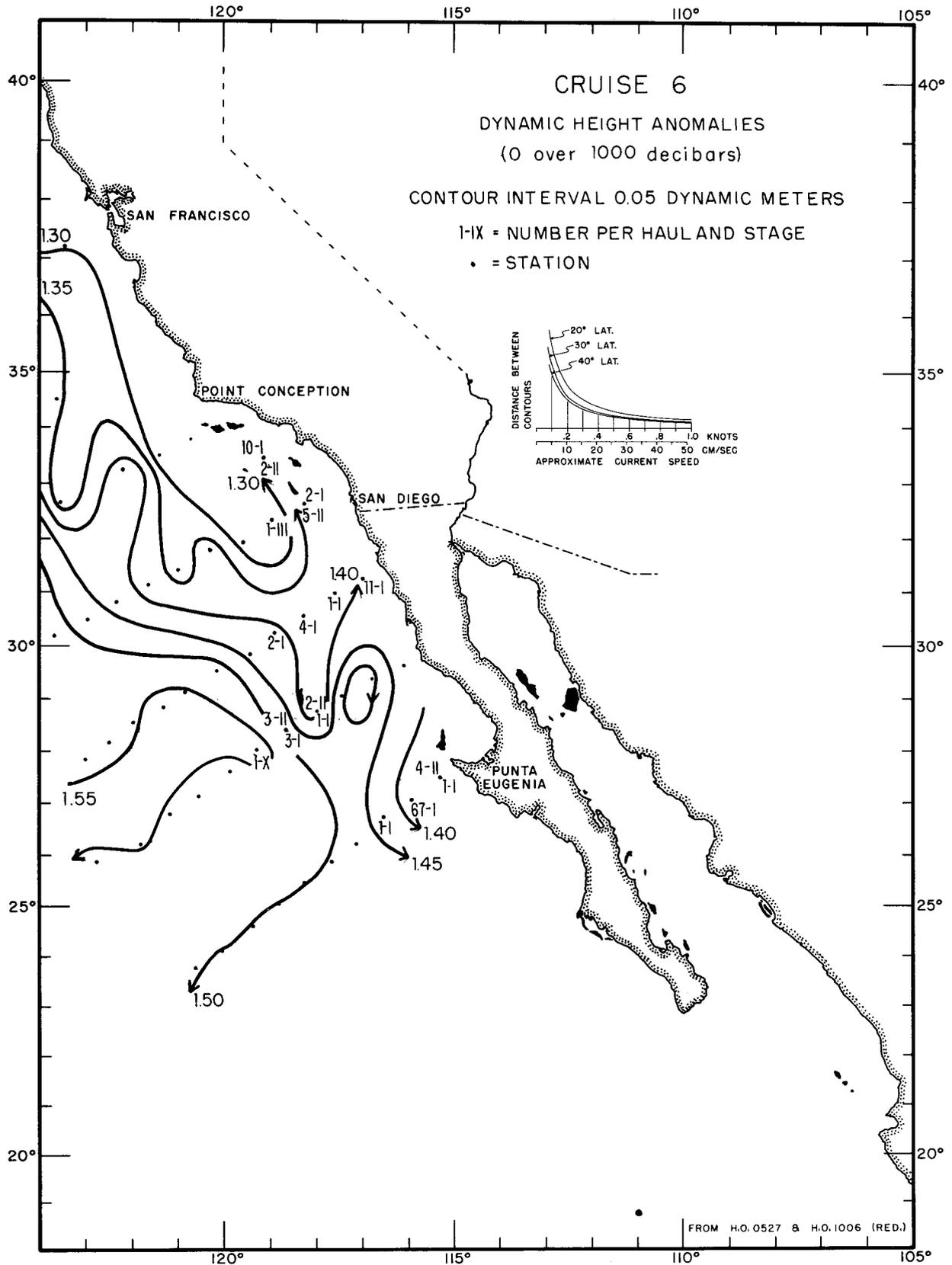


FIGURE 143. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during August 2 to 22, 1949 (MLR Cruise 6).

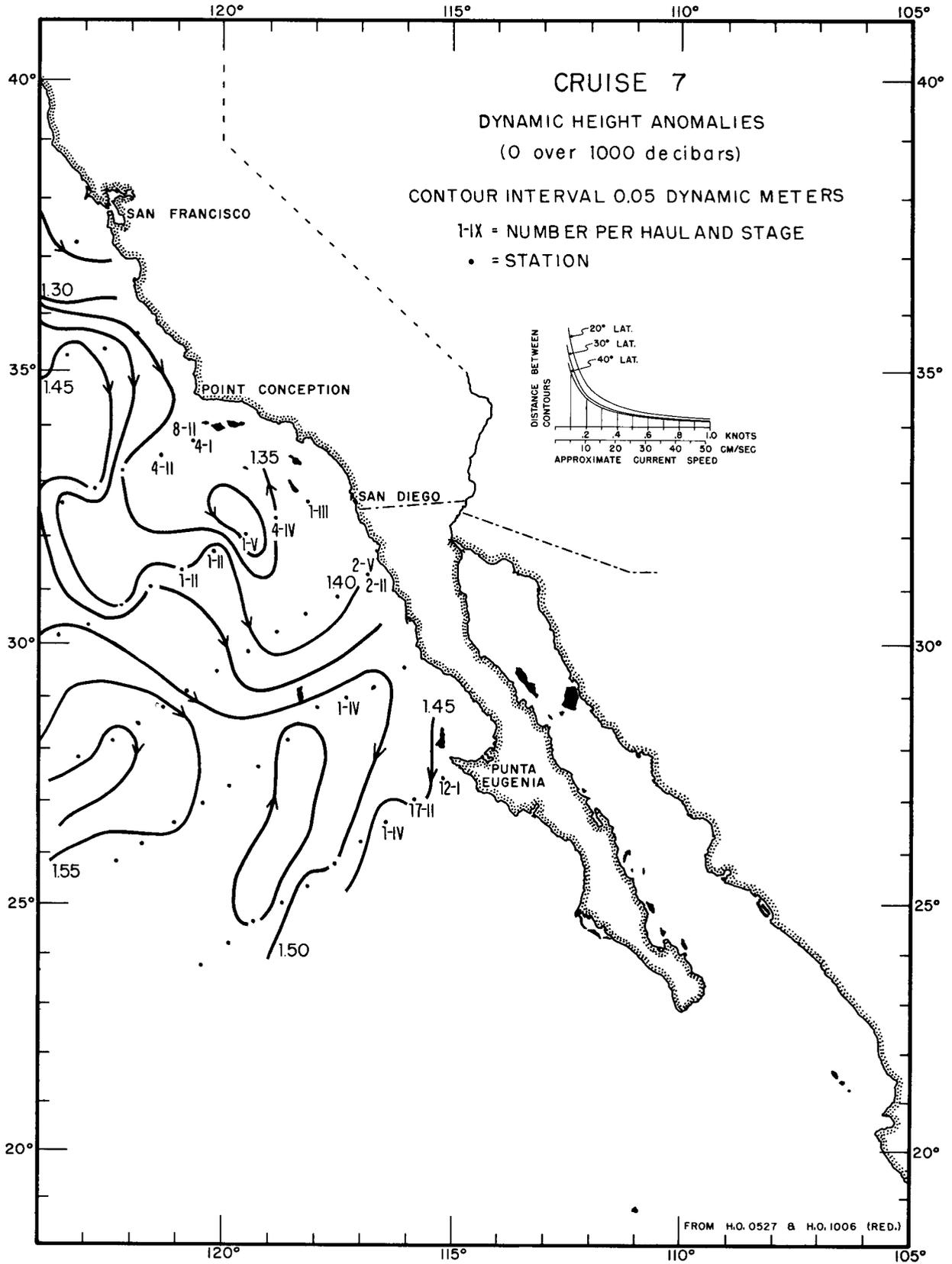


FIGURE 144. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during September 4 to 18, 1949 (MLR Cruise 7).

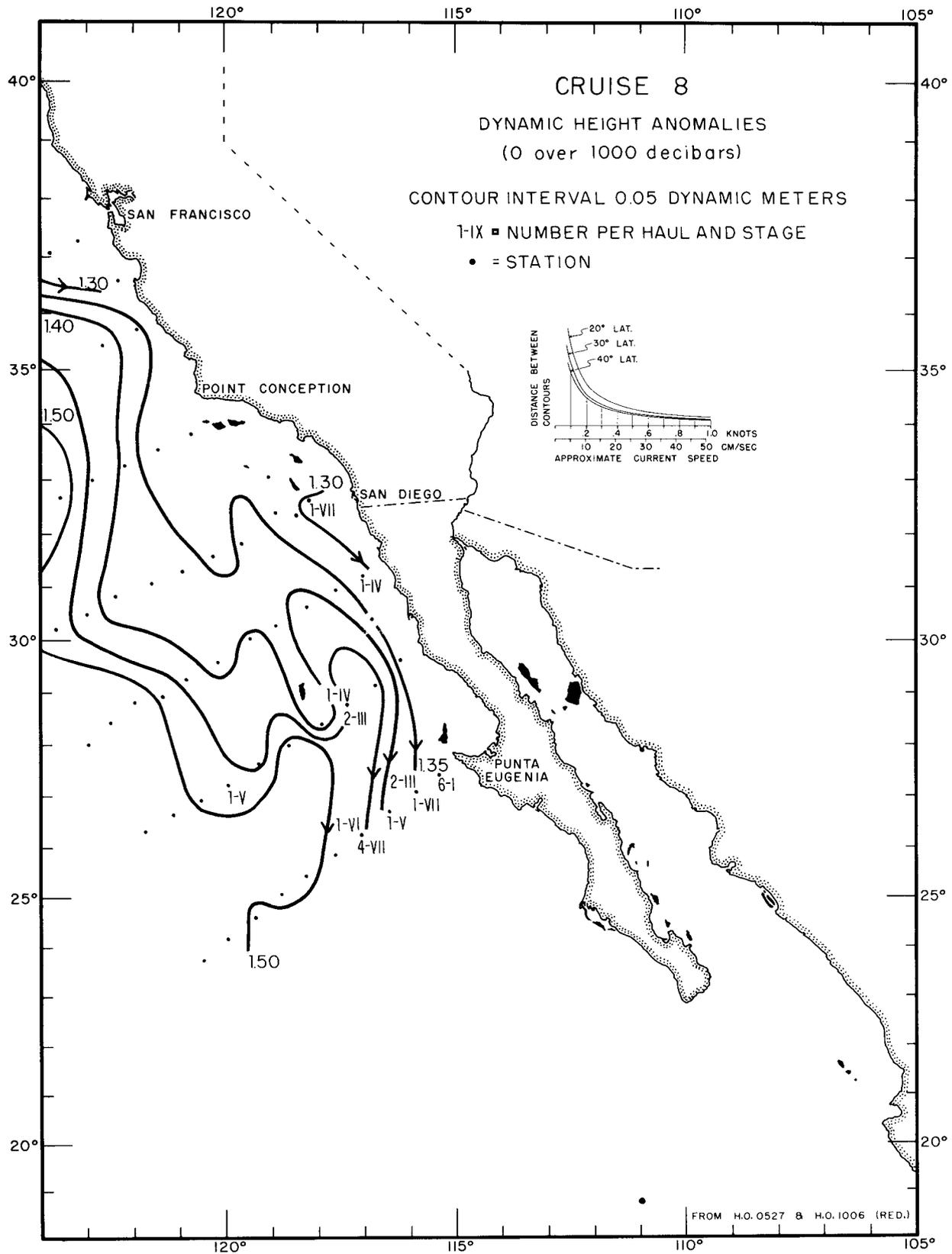


FIGURE 145. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during October 4 to 19, 1949 (MLR Cruise 8).

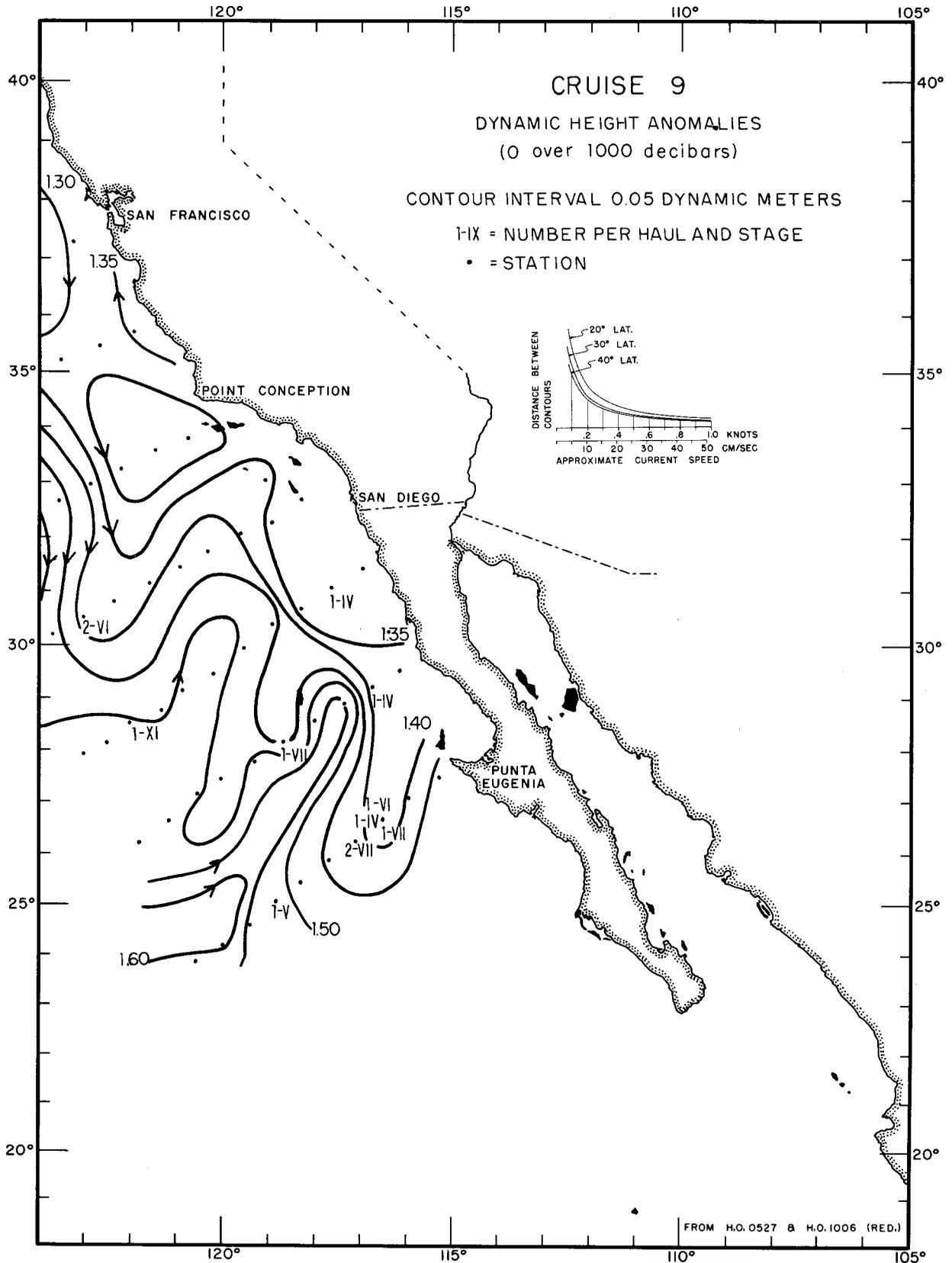


FIGURE 146. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 1000 decibars) during November 8 to 25, 1949 (MLR Cruise 9).

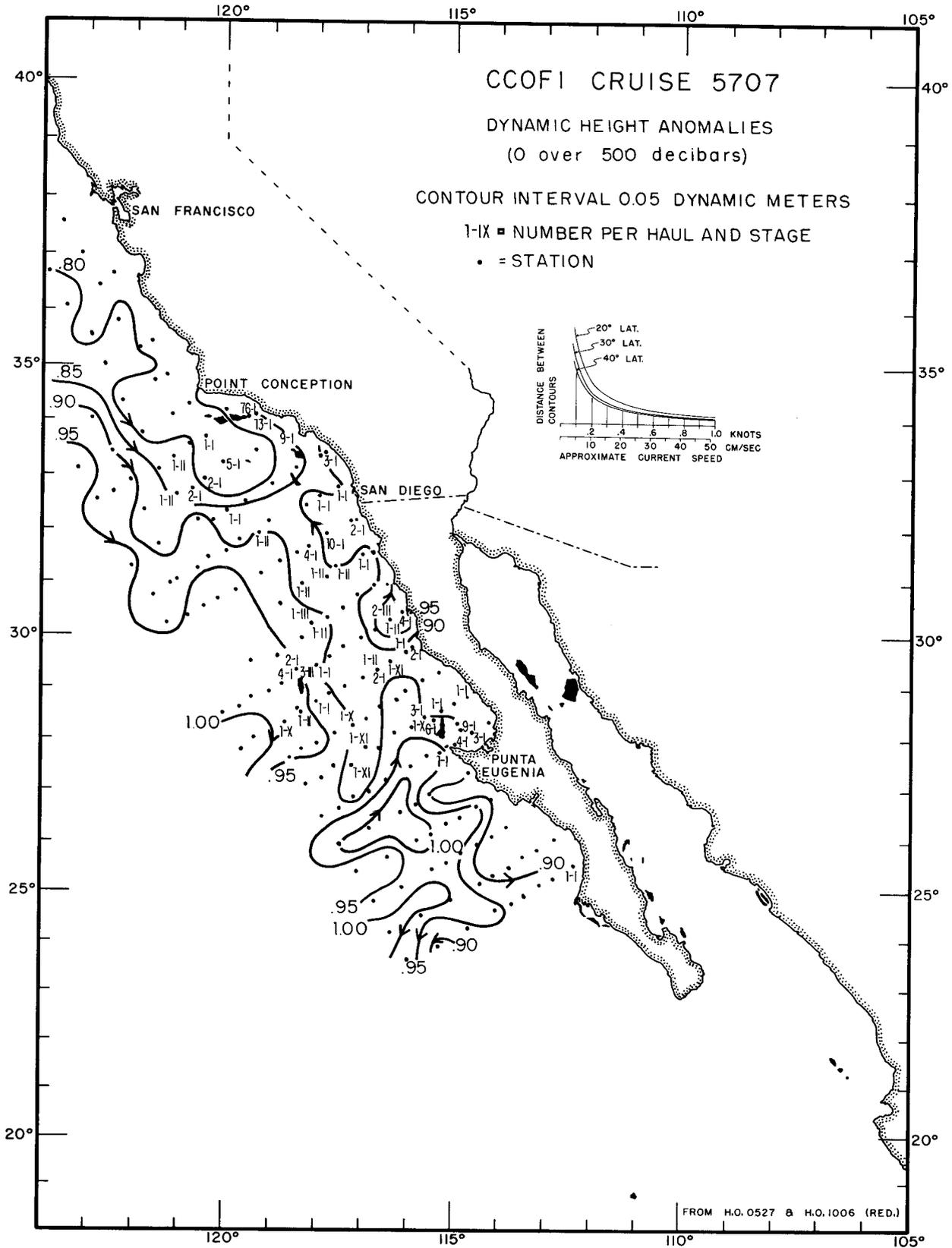


FIGURE 147. Locality records for *Panulirus interruptus* larvae and dynamic height anomaly (0 over 500 decibars) during July 8 to August 3, 1957 (CCOFI Cruise 5707).

