ECHO SOUNDER EVIDENCE

OF

DIURNAL VERTICAL MIGRATIONS OF HAKES

By Robert L. Edwards* and Robert Livingstone, Jr. *

ABSTRACT

Evidence for diurnal migrations of two species of hakes (Merluccius) has been observed on the Albatross III Edo Echosounder. The data are presented and discussed.

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The diurnal behavior of the silver hake has always been a subject of considerable discussion amongst fishermen. Many trawler fishermen will attest to the fact that these fish come up to the surface at night and accordingly do not fish for them at this time. Others say that the silver hake is as abundant and catchable at night as it is by day.

Further evidence of vertical migration in Merluccius species is seen in studies of their feeding habits by Davies (1949), and Hickling (1927). That Merluccius may be sounded and taken in mid-water in good quantity has been demonstrated by Schaefers and Powell (1958). Before World War II, mackeral drift gill net fishermen often caught silver hake in their nets at night, sometimes in quantity and usually, as some have reported, when the moon was bright.

On cruise 126 of the Albatross III in January and February 1959, we obtained further evidence that both the silver hake (Merluccius bilinearis) and its close relative, the American hake (M. albidus), make vertical migrations of considerable magnitude. The primary purpose of cruise 126 was to survey the fishes of the Continental Shelf in the area between Cape Hatteras and Cape Cod. The data were specifically collected as part of a study of the roles of temperature and depth in the distribution of fishes. Whenever possible, detailed notes were made on the echo-sounder (Edo-AN/UQN-1B) recordings for comparison with the fish actually

captured. While making these notes, we became aware of what seemed to be significant relationships between the recordings--their type, density, and position relative to the bottom--and the fish that were caught on that station. The stations referred to in this paper are indicated on figure 1.

Fig. 1.--Stations occupied on Cruise 126 of Albatross III, January and February 1959. (Only stations referred to in text and table 1 are shown.)

Late in the afternoon of January 25, on station 6-6 (see figure 1) off the mouth of Chesapeake Bay, an intensely developed scattering layer was noted on the sounder. This layer was subsequently observed at practically all stations along the shelf from 100 fathoms out to 275 fathoms (our maximum fishing depth). It was further observed to leave the bottom late in the afternoon and return to the bottom in the morning. The behavior of the layer was markedly similar to that reported for the better-known deep scattering layer in that it sometimes consisted of more than one layer and also exhibited similar diurnal movements (cf. Hersey and Backus, 1954).

When first observed the recordings were regarded more with curiosity than with interested intelligence since we did not consider the layers to be produced by fishes. However, as the cruise continued, it became increasingly apparent that the recordings of these layers bore some relation to our catches.

The traces that appeared were often double-layered, as can be seen in figure 2. Both layers are descending here at a

Fig. 2.--The scattering layer descending early in the morning. Notice the double nature of the trace. The bottom part of the layer descended to the bottom, a distance of about 100 fathoms, in less than 1 hour. The top part reached the bottom (at 150 fathoms) about 0800.

relatively rapid rate shortly after daybreak. On this station, 10-1, where the lower portion returns to the bottom toward the end of the tow, 62 albidus were taken and no bilinearis. Figure 3,

Figure 3.--The scattering layer ascending in late afternoon. The upper trace rose to the surface from about 130 fathoms in slightly more than 1 hour. The lower trace is only faintly apparent and is beginning to rise after the tow was completed. A persistent bottom trace, usually associated with white and/or red hake, may be observed.

station 9-7, shows the scattering layer leaving the bottom late in the afternoon. The upper portion is lifting as the tow begins; the lower portion may be clearly seen lifting after the tow was completed. A relatively large number of bilinearis were taken (850),

but not so many albidus (27). On station 9-6, figure 4, where

Fig. 4.--An early afternoon trace, showing distinctive upper and lower traces. Notice that the upper trace touches bottom at 125 fathoms, otherwise it maintains a level, occasionally paralleling the bottom contour.

there is a stronger, lower trace on the bottom, with the upper, heavy trace generally off the bottom, a relatively large number of albidus were taken (125) compared with bilinearis (425). On station 4-8, figure 5, one trace, the upper, is clearly off the

Fig. 5.--An exceedingly heavy upper trace, generally off the bottom with an irregular lower trace. A heavier spotting, believed to be representative of white hake, may be seen on original tracing at slope where tow began.

bottom for the entire tow while the other, lower trace was right on the bottom for much of the tow. Here 127 albidus were taken, no bilinearis. On tow 1-2, figure 6, where these traces were clearly

Fig. 6.--A heavy but undifferentiated hake tracing on the bottom. A heavy catch of both M. bilinearis and albidus was made here.

on the bottom, large quantities of both species were taken (see table 1).

Table 1.--Number of "hake" and other species taken in 30-minute tows with remarks on the echo sounder traces

Date	Station number	Location N. Lat.	Location W. Long.	Time	Depth in fathoms	Catch per 30-minute tow No. individuals: American hake	Silver hake	White hake	Red hake	Others	Trace characteristics
Feb. 3	1-1	39° 58'	70° 19'	0700-0730	197 (182-238)1/	72	280	26	105	68 long-finned hake 34 greysole	2 diffuse layers 100-180 fm; descending and merging on bottom at 180 fm.
do	1-2	40° 00'	70° 17'	0805-0830	165-128	520	600	---	158	----	Layer on bottom, another diffuse band at 20-40 fm. (Fig. 6).
do	1-3	40° 03'	70° 13'	1000-1030	100	---	---	---	---	1500 butterfish 428 spiny dogfish	Diffuse trace on bottom during tow, two bands in midwater.
do	1-4	40° 06'	70° 14'	1227-1257	82-83	---	---	---	---	277 butterfish 367 spiny dogfish	1 layer from 6-18 fm. below surface.
do	1-5	40° 09'	70° 17'	1421-1451	65-63	---	---	---	---	----	Nothing during tow; single band 27-30 fm. seen when vessel not moving after tow.
do	1-6	40° 22'	70° 20'	1645-1715	48-45	---	---	17	---	57 spiny dogfish	Nothing on bottom. Many scattered "finger nail" type traces (Cushing, 1957) from 2-25 fm.
Jan. 24	4-8	37° 57'	73° 56'	1612-1642	240-200	127	---	46	---	30 angler	Strong layer occasionally in contact with bottom. Other midwater traces (Fig. 5).
Jan. 31	5-6	37° 34'	74° 16'	1510-1545	224 (175-272)1/	63	---	49	---	29 long-finned hake	Layer mostly about 6 fm. off bottom deeper than 200 fathoms.
do	5-7	37° 36'	74° 16'	1633-1703	105-180	---	350	---	61	Squid 25 spiny dogfish	Layer on bottom at 100 fm. similar to that in Fig. 6.
Jan. 25	6-6	36° 46'	74° 38'	1458-1528	177 (90-230)1/	24	108	---	---	45 angler	Layer at and on bottom at 150 fm.
Jan. 27	7-5	35° 47'	74° 51'	1341-1411	68-92	---	123	---	---	----	Diffuse band 50-65 fm. in contact with bottom at start of tow.
do	7-6	35° 45'	74° 50'	1449-1519	158 (106-226)1/	4	332	---	---	50 shrimp	"Finger nail" type trace 100-130 fm. Diffuse scattering as depth increases, then diffuse layer capped by heavy band (Fig. 7).
Feb. 1	9-5	38° 24'	73° 24'	1321-1351	123-112	---	900	---	49	-----	Layer at bottom at 110 fm. similar to that in Fig. 3 but less extensive.
do	9-6	38° 25'	73° 23'	1424-1454	200 (165-220)1/	125	425	21	---	----	Layer intensely developed with level changing relative to bottom contour (Fig. 4).
do	9-7	38° 33'	73° 14'	1638-1708	149-156	27	850	15	17	----	Complex layer on bottom. First 20 min. of tow, then double layer ascending and merging (Fig. 3).
Feb. 2	10-1	39° 27'	72° 06'	0645-0715	220-230	62	---	5	---	----	Double layer descending lower layer in contact with bottom at end of tow (Fig. 2).
do	10-2 2/	39° 31'	72° 06'	0801-0831	200-157	90	---	16	36	----	Nothing during tow but intensely developed at 150 fm. following haulback when ship quiet in water.

1/ Average depth fished plus range.

2/ Net partially fouled.

In those areas where white hake (Urophycis tenuis) were taken, there was usually a discernibly heavier trace right on the bottom. This trace may be observed in figure 5 on the descending slope just to the right of the beginning line of the tow. We were unable to identify any particular type of trace with the presence of red hake (Urophycis chuss).

Occasionally a "finger-nail" type of trace was observed associated with catches of M. bilinearis (fig. 7).

Fig. 7.--An unusual type of tracing associated with M. bilinearis. Notice tendency for concentration of fish at roughly same depth despite change in depth of bottom. Water temperature at this level (120 fathoms) is about 52° F.

All of the pertinent data are summarized in table 1. These data and the observations discussed have convinced us that we were in fact observing well defined traces of at least the silver and American hakes. In winter, silver hake are found in number along the edge of the Continental Shelf down to 150 fathoms. At this depth and deeper, albidus may be taken, occasionally in number as well. The double trace occurred only in depths at which it was possible to catch both species, i. e., depths usually in excess of 125 fathoms. The traces are separated vertically, the presumed bilinearis trace being on top. This double trace may be observed leaving the bottom late in the afternoon and rising to near the surface in an hour or so, always maintaining some degree of vertical separation. They descend in the morning at about the same rate.

The bilinearis trace doesn't usually descend much below 125 fathoms, however it may extend offshore at this level into waters of great depth. Figures 4, 5, and 7 show such bilinearis traces at mid-depths. In each of these cases the water temperature was approximately 52° F. at trace depth. This temperature appears to be the preferred temperature of the offshore silver hake, based on the trawl data obtained on cruise 126.

In the shallower depths, the albidus trace diminishes rapidly and was never observed at less than 100 fathoms. The albidus trace has also been observed extending out into waters of great depth, descending several hundred fathoms.

One further piece of evidence that we were in fact observing vertical migrations of silver hake on the echo sounder presented itself when the catch on station 9-7 was examined. The silver hake caught at this time were not, as was usually the case, severely bloated or otherwise obviously damaged by decompression of the swim bladder. As mentioned previously, this catch was made in late afternoon when the upper, or bilinearis, trace was lifting off the bottom. It would appear that these hake have a mechanism, perhaps keyed in with changes in light intensity, that enable them to adjust the air bladder for a relatively rapid upward migration. Certainly silver hake caught during the day are badly damaged as a result of their rapid ascent to the surface in the net and obviously do not adjust for the pressure change at this time.

Davies' paper, (1949), on the Foods of South African Fishes, is a particularly pertinent reference to our general thesis. Our own Middle Atlantic area and the species found there show many similarities to those fishes of the southwest coast of Africa, which Davies studied.

Davies (op. cit.) reports: "It appears that the Cape stockfish (Merluccius capensis) is almost entirely a pelagic feeder, and, judging from its behaviour in relation to trawling, feeds during the night near the surface and rests near the bottom during the day. Large numbers of stockfish are caught in the otter trawl nets at depths in the neighborhood of 200 fathoms (366 metres) during the day by commercial trawlers, while a long drag at night will generally yield very few fish. Line fishermen working at night, however, often catch stockfish very near the surface." The Cape stockfish is more closely related to the deep water M. albidus than to the better known silver hake (M. bilinearis). The fishing grounds referred to by Davies is a deep water area and the bulk of the samples he concerned himself with came from an area circa 200 fathoms in depth.

The need for mid-depth gear to empirically investigate the nature of these scattering layers is obvious, especially since rather large concentrations of hake (more than 5,000 lbs. of M. productus in a 20-minute tow with a mid-depth trawl) have been recorded in mid-water in the Pacific (Schaefers and Powell, 1958).

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October 25, 1960

Acting Laboratory Director, BCF,
Woods Hole, Mass.

Ms., "Evidence of diurnal vertical migrations of hakes,"
by Edwards and Livingstone.

Thank you for your memo of October 20 on the manuscript. Since rewriting it we have further documented the occurrence of hakes at the surface.

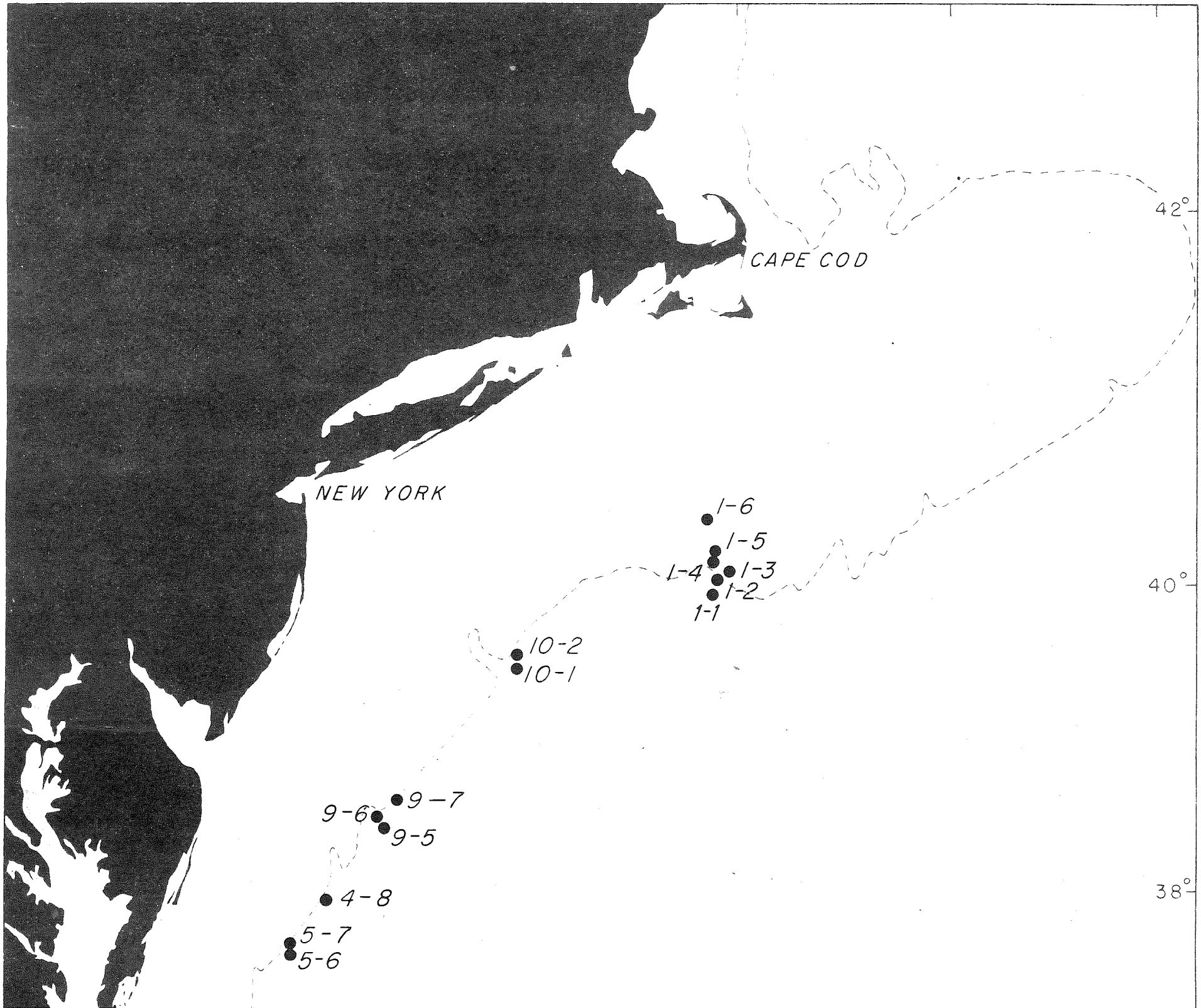
At this very moment, Ray Fritz and Bob Livingstone are aboard the Delaware checking out the new echo-sounder with an eye toward a scheduled cruise this spring. We hope to fish "Alexander's Acres" with an Issac's Kidd to demonstrate empirically the nature and magnitude of these migrations.

It has always been our hope that we would be able to catch silver hake and American hake at the surface offshore in sufficient quantities to make tagging operations feasible. We feel that we could learn more about these populations in this manner than we could otherwise at this time. Be assured that we have no intention of letting any opportunities pass us by!

cc: BCF, Region 3
jah

Robert L. Edwards

Cover. --Sorting the catch on station 4-8, off Ocean City, Maryland. The catch includes white hake, American hake, anglers, and the red crab Geryon (in basket at left).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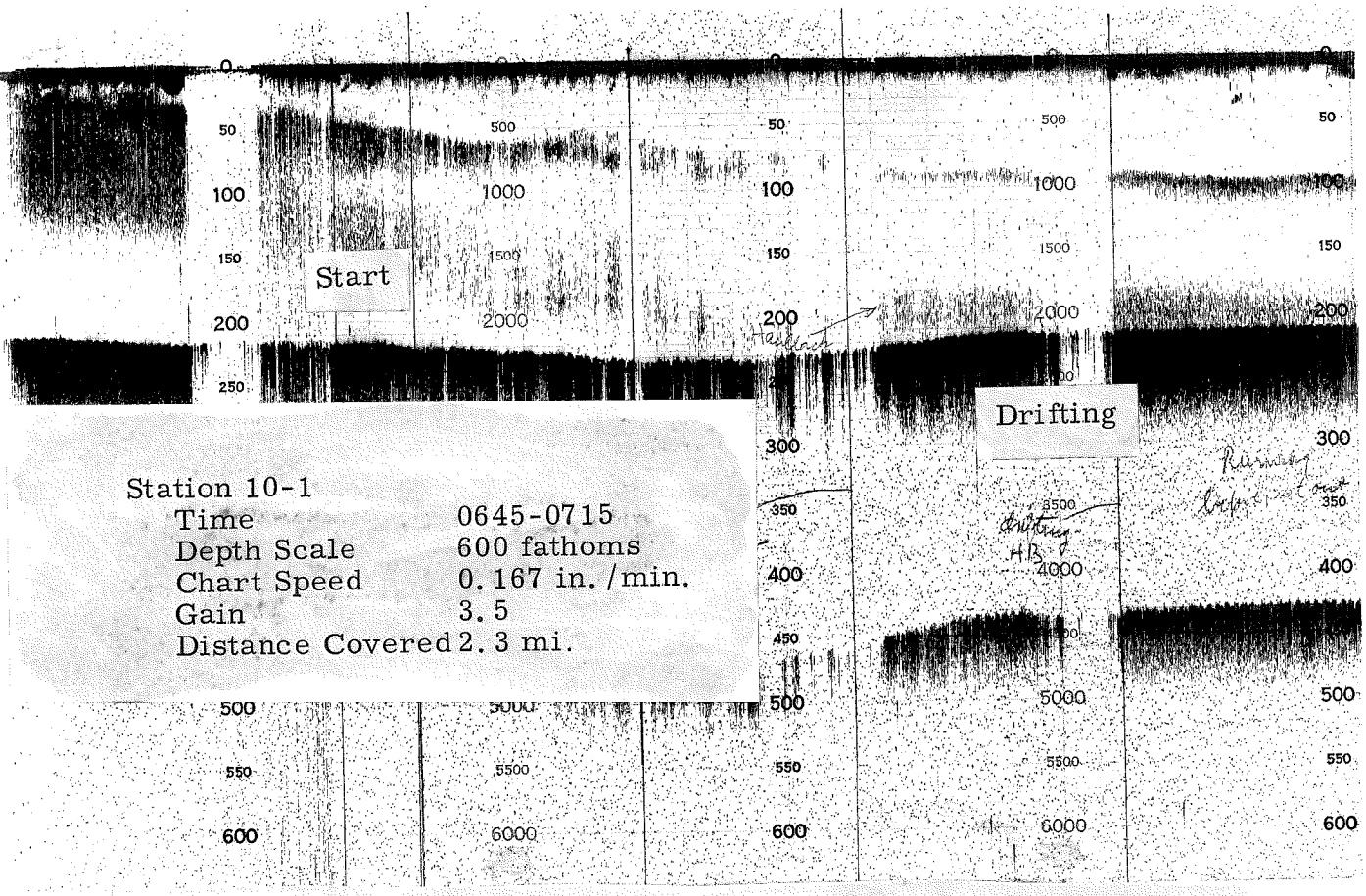

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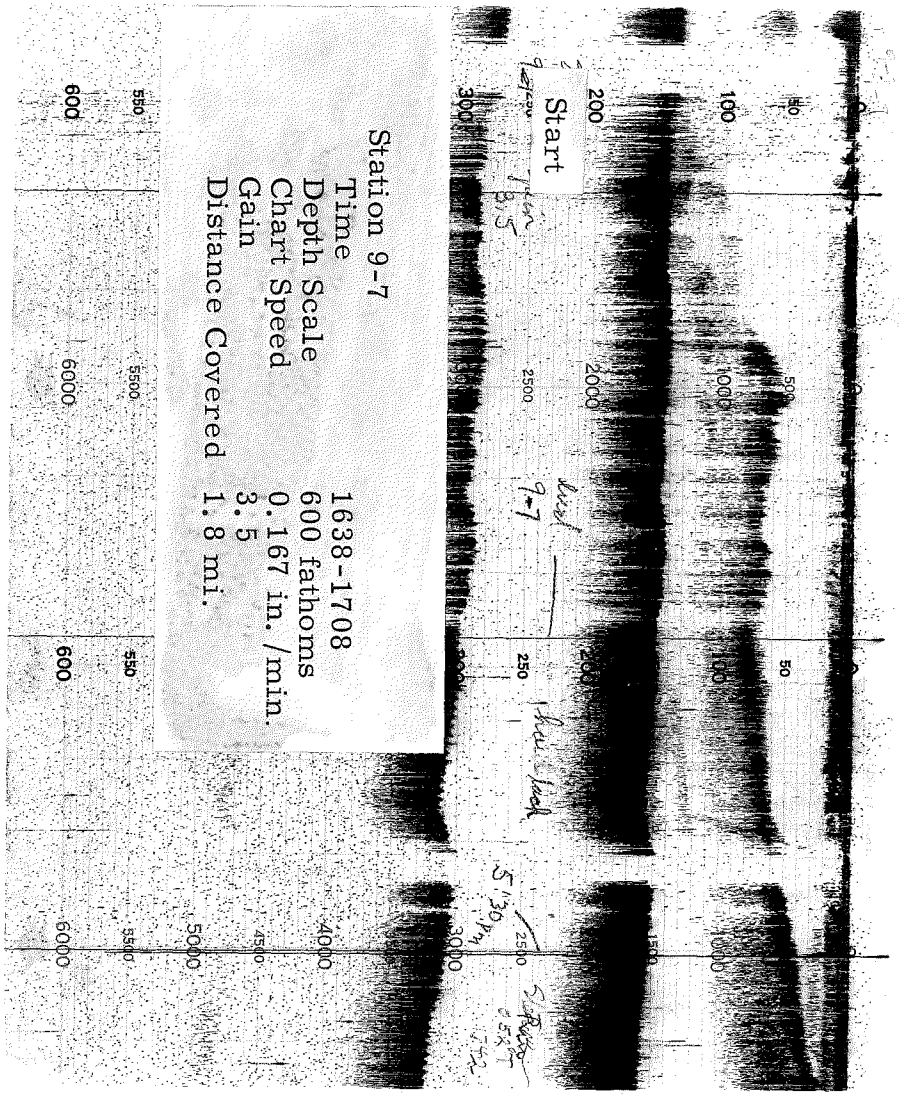

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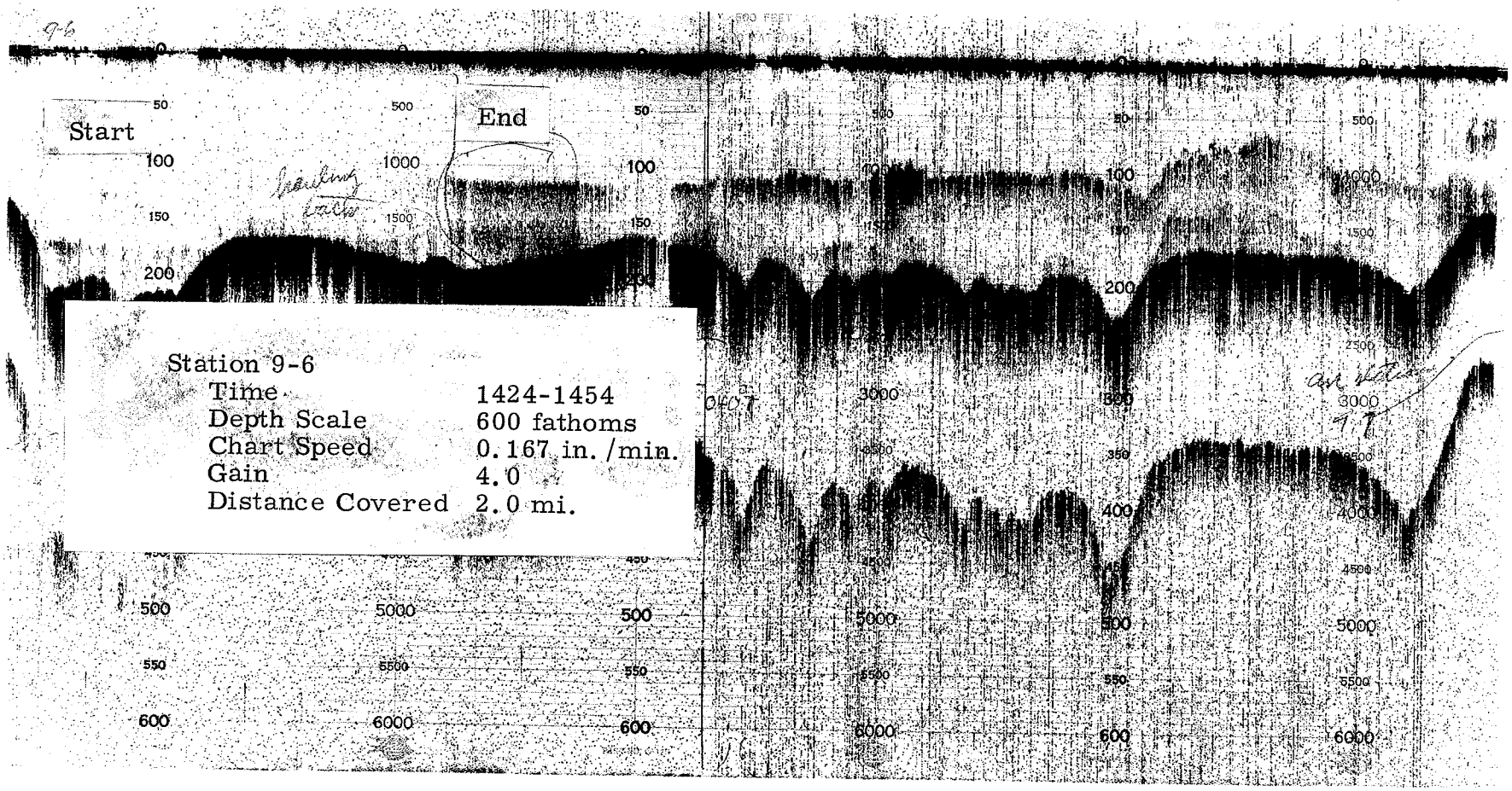

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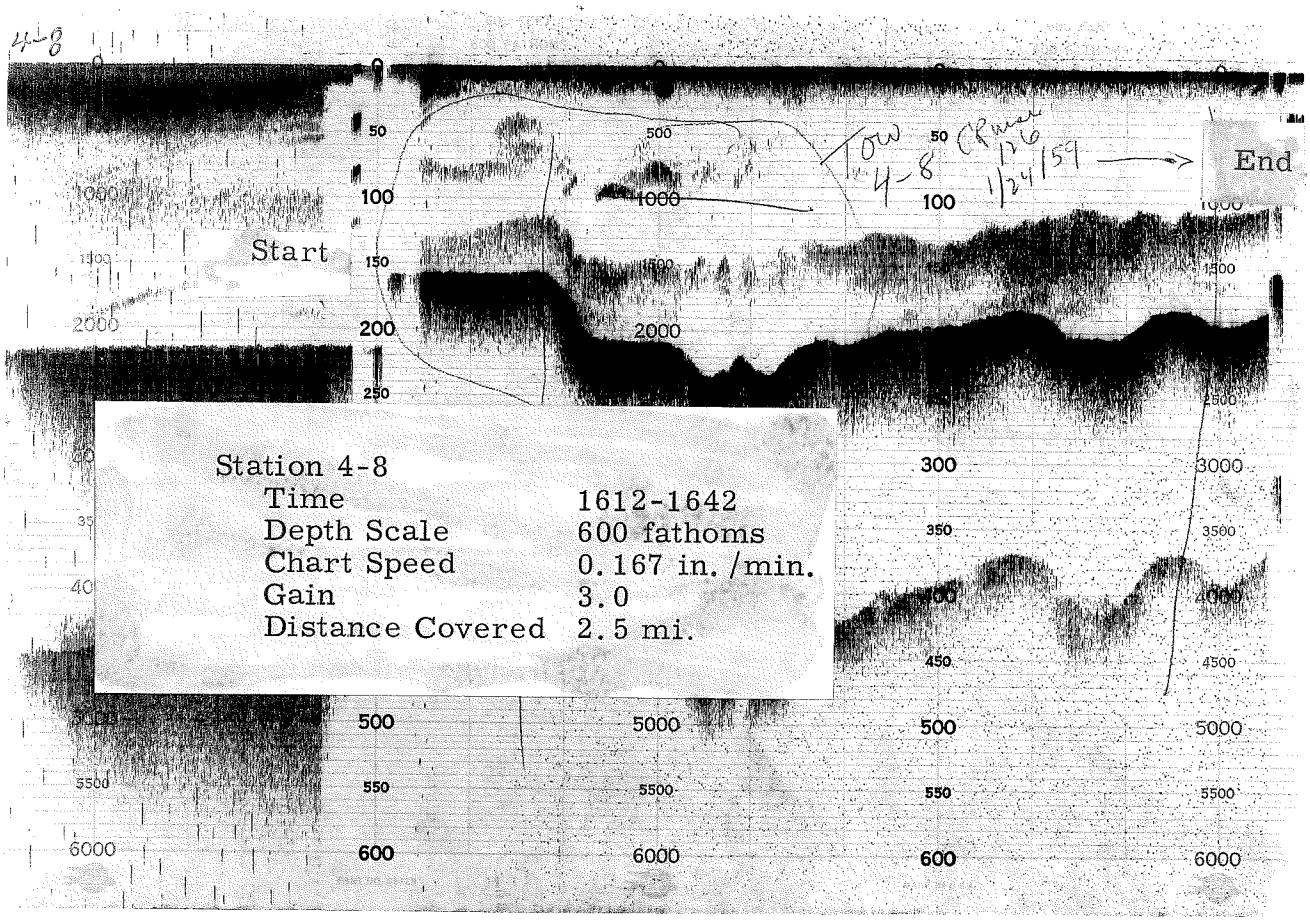

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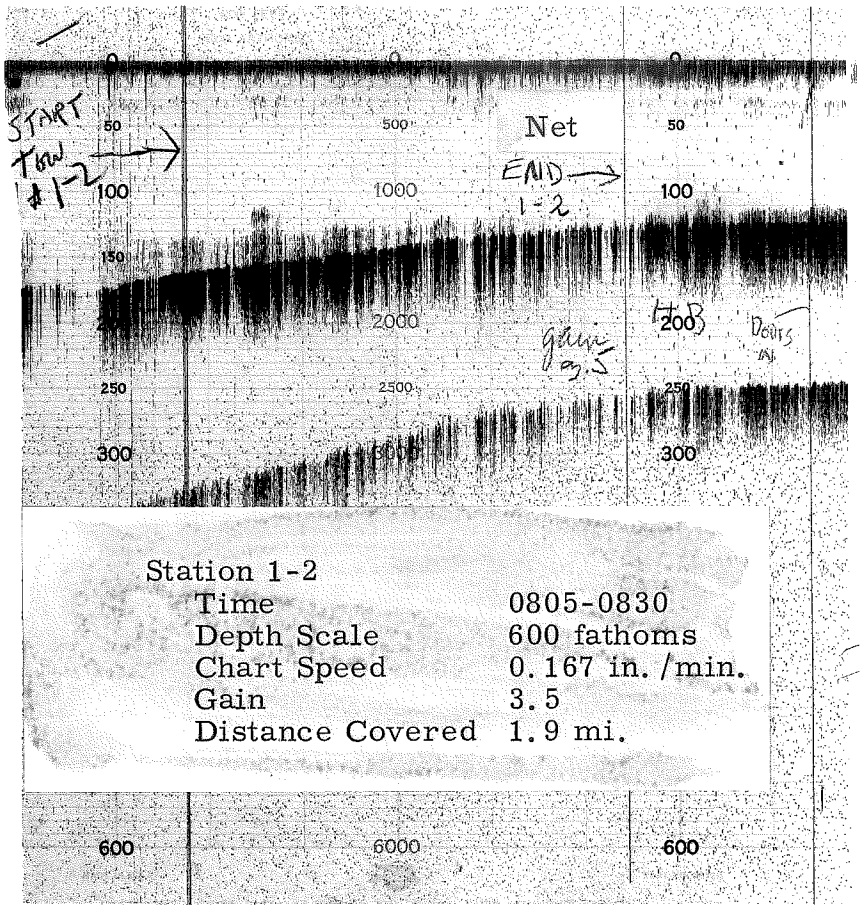

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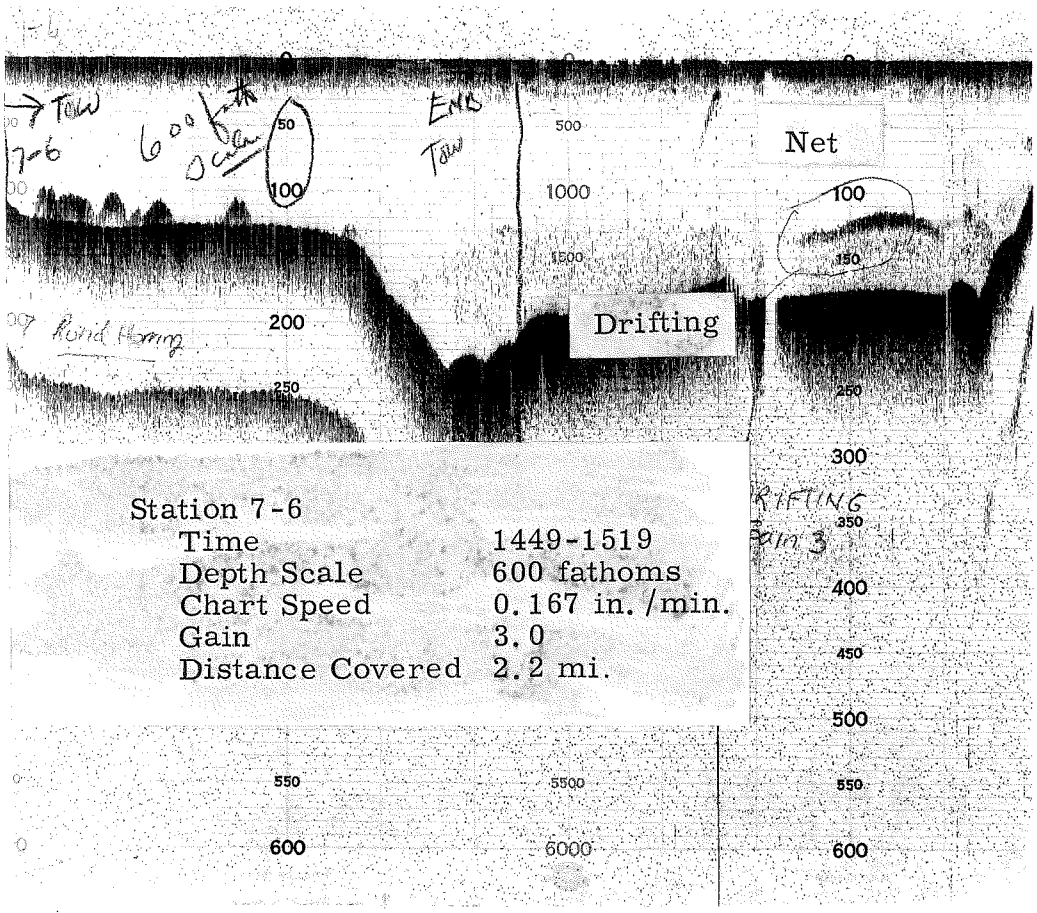

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