NPAFC
Doc.214
Rev. ___

Vertical Distribution of Salmon Determined by an Acoustic Survey in the North Pacific Ocean in the Winter of 1996

by

Junko Sakai, Yasuhiro Ueno, Yukimasa Ishida,
National Research Institute of Far Seas Fisheries

and

Kakusuke Nakayama
Fisheries Research Vessel *KAIYO MARU*

Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
by
JAPAN
October 1996

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Sakai, J., Y. Ueno, Y. Ishida, and K. Nakayama. 1996. Vertical Distribution of Salmon Determined by an Acoustic Survey in the North Pacific Ocean in the Winter of 1996. (NPAFC Doc. 214.). National Research Institute of Far Seas Fisheries. 5-7-1 Orido, Shimizu, Shizuoka, 424, Japan. 13p.

Vertical Distribution of Salmon Determined by an Acoustic Survey in the North Pacific Ocean in the Winter of 1996

Junko Sakai[1], Yasuhiro Ueno[1], Yukimasa Ishida[1],
and Kakusuke Nakayama[2]

[1] National Research Institute of Far Seas Fisheries
[2] Fisheries Research Vessel *KAIYO MARU*

ABSTRACT

We conducted surveys for Pacific salmon in the North Pacific Ocean in January 1996. We caught salmon by trawl net at the predetermined stations. At the same time, we also made acoustic survey along the line between and over the stations using a quantitative echo sounder with frequency of 50.0kHz and depth range of 200m. Clear marks recorded on wet recording papers were read as signals from fish and we counted these marks. The zonal acoustic counts corresponded fairly well to the catch in number by trawl net. Acoustic data also showed that salmon were not below the salinocline and in the waters colder than 4℃. Most of salmon were found in the waters where the temperature is between 4℃ to 8℃ and in the depth of 25m to 55m. Analysis of the difference in vertical distribution between daytime and nighttime showed that much fewer salmon were found in the nighttime with the echo sounder.

INTRODUCTION

There are several reports of acoustic survey on salmon in coastal waters and rivers (Tarbox and Thorne 1996), but we have little information about the vertical and horizontal distribution of salmon in the oecan detected by acoustic methods. We did not even know well how we can detect salmon in offshore waters with acoustic instruments, because salmon are believed to make no school and to be hardly found in the ocean. However, there was no attempts to confirm these beliefs and to examine the possibility of acoustic salmon stock assessment. In this research, we tried to find salmon with a quantitative echo sounder during the salmon research cruise by Japanese research vessel *KAIYO MARU* in the North Pacific Ocean in the winter of 1996.

METHODS

We conducted surveys for Pacific salmon aboard the R/V *KAIYO MARU* (2,942 gross ton) in the North Pacific Ocean from January 8th to 25th of 1996. We made 23 trawl net operations to catch Pacific salmon. Acoustic surveys were made intermittently from January 10th to 27th with a quantitative echo sounder along the line as drawn in Figure 1.

The echo sounder used is Furuno's FQ−72 with frequency of 50.0kHz, and depth range of 200m. After calibrated with TVG (Time-Varied Gain), acoustic data were recorded on wet recording papers. Clear marks on recording papers were read as signals from fish and we counted these marks. Besides, we recorded echo integrated data by 100pings, which is equal to about two minutes.

RESULTS AND DISCUSSION

Relation between Salmon Found in Acoustic Surveys and Trawl Catch

We towed a trawl net at 18 stations while echo sounder worked, and we caught salmon at 13 stations among them (see Figure 1). Figure 2 shows the correspondences of acoustic counting to catch by trawl net per 60 minutes. Horizontal axis is the distance which the vessel proceeded versus catch in number of salmon at each station in logarithmic scale (top) and the point and depth in which we detected salmon, superimposed on water temperature in ℃ (center) and salinity in psu(bottom). The numbers connected with hyphen indicate the station numbers, at those stations we made trawl net surveys.

The species compositions of catch by trawl net suggest that there is no substantial incidental catch which could affect the response to echo sounder, so we can say almost all fish we detected with the echo sounder are salmon. On the basis of these results, we can see that catch in number of salmon at a station corresponds well to the number detected by the echo sounder around the station.

Relation between Salmon Habitat and Environment

Relating the distribution of salmon to water temperature, no salmon were found in the waters colder than 4℃. The upper limit of temperature for salmon existence does not appear in these diagrams (see carefully the section where acoustic surveys were not made). But we can see most salmon were found in the water warmer than 4℃ and colder than 8℃. We also see that all salmon were above the salinocline around 33.5psu, although there was not clear thermocline because of winter conditions.

The fact, that the salinity distribution dominates the salmon distribution, suggests that the construction of water masses determine the distribution of salmon. In other words, salmon may have a tendency to habit in particular water masses. We need further analysis of this aspect.

Vertical Distribution of Salmon

In order to discuss about quantitative echo data of fish, we must essentially calibrate the volume that the beam of echo sounder sweeps, because the cross section that the beam traverses is larger in deeper zone. But sensitivity of recording paper is considerably low, so the angle of the beam becomes much narrower than the equivalent beam angle determined by the characteristics of echo sounder itself. Then we could not determine the sampling angle of the beam and could not calibrate the numbers of salmon found with echo sounder by depth.

Figure 3 shows vertical distribution of salmon found with all data (257 individuals). In general, many salmon are found between 25m and 55m deep (Figure 3). There are some differences between the following three areas. The depth that many salmon were found is shallower in the western North Pacific (15m to 35m) , and deeper in the central (25m to 50m) and the eastern(20m to 80m). In the western North Pacific, no salmon were found deeper than 80m.

However, before we conclude that salmon generally habit in shallower waters in the western North Pacific than in the eastern North Pacific, we must examine environmental, acoustical or biological problems. For example, we could not find salmon in the western North Pacific in deeper zone than 80m, three possibilities exist for this feature. First of all, the waters colder than 4℃ exist in shallower layer in the western North Pacific than in the central and eastern North Pacific (see Figure 2). Secondly, salmon caught in this area were considerably small, so the target strength of their body would be in low level, then we could not detect them in such deep zone. Finally, according to the fork lengths of the salmon caught, salmon in this area were yearlings, and they may inhabit in shallower zone than older ones.

Effect of the problem of contents of species does not exist, because the abundance of chinook salmon, which migrate in deeper waters than chum, pink and sockeye salmon, in these areas is assumed to be very small.

Analysis of the difference between vertical distribution in the daytime and in the nighttime showed that merely a few individuals were detected in the nighttime. There is not a clear peak of number in the nighttime, by depth, which appears in the case of the daytime. Recognizing the depth of draft of research vessel (depth of the transducer), that fact does not contradict the results that salmon go up shallower zone in the nighttime (see Ogura and Ishida,1995, for example).

CONCLUSIONS

We made acoustic surveys of salmon in the North Pacific Ocean in winter. Here are the conclusions from these surveys below:

1. We found that we can detect individual salmon with echo sounder. This means that there is possibility of assessment of salmon abundance with acoustic methods.
2. With very simple method of acoustic echo counting, the zonal counts corresponded fairly well to the catch in number by trawl.
3. Although there was no clear thermocline because of winter conditions, salmon were not below the salinocline. Most of them were found in the waters whose temperature were between 4℃ to 8℃. Relation to salinity seemed to suggest the connection between salmon and water masses.
4. Most salmon were found in the depth of 25m to 55m. This was consistent with the result in the daytime.
5. We could see much fewer salmon in the nighttime with echo sounder attached to the bottom of the ship. We considered this was due to the habit of salmon going up to surface in the night.

Despite these conclusions, we must admit that this survey is far from perfect as an acoustic survey. First of all, as we mentioned in former section, the dynamic range of recording paper is narrow, so we might find fewer fish than they were. Secondly, because this survey is not pure acoustic survey, the ship run too first to detect fish. We should be more careful in the case of taking quantitative data.

In addition, we have essential problem in this type of surveys. While the molded draft of the vessel is 6 m, a salmon survey with depth sensing transmitter indicated that the rate of appearance of chum, sockeye and pink salmon is about 50% in the depth shallower than 5 m (Ogura and Ishida, 1995). We can not find fish in such shallow waters with a echo sounder, whose beam direction is perpendicular to water surface, attached to the bottom of a research vessel. In further experiments, we need some new ideas or instruments to detect fish in such shallow depth. We are planning to use other type of echo sounder and sonars with trawl net.

ACKNOWLEDGMENTS

We wish to thank Mr. Yoshimi Takao, National Research Institute of

Fisheries Engineering, for giving a lot of useful comments to this work.

REFERENCES

Ogura, M. and Ishida, Y. 1995. Homing behavior and vertical movements of four species of Pacific salmon in the central Bering Sea,. Can. J. Fish. Aquat. Sci., 52, 532-540.

Tarbox, K. E. and Thorne, R. E. 1996. Assessment of adult salmon in near-surface waters of Cook Inlet, Alaska. ICES Journal of Marine Science, 53:397-401.

(We referred to some other papers written in Japanese.)

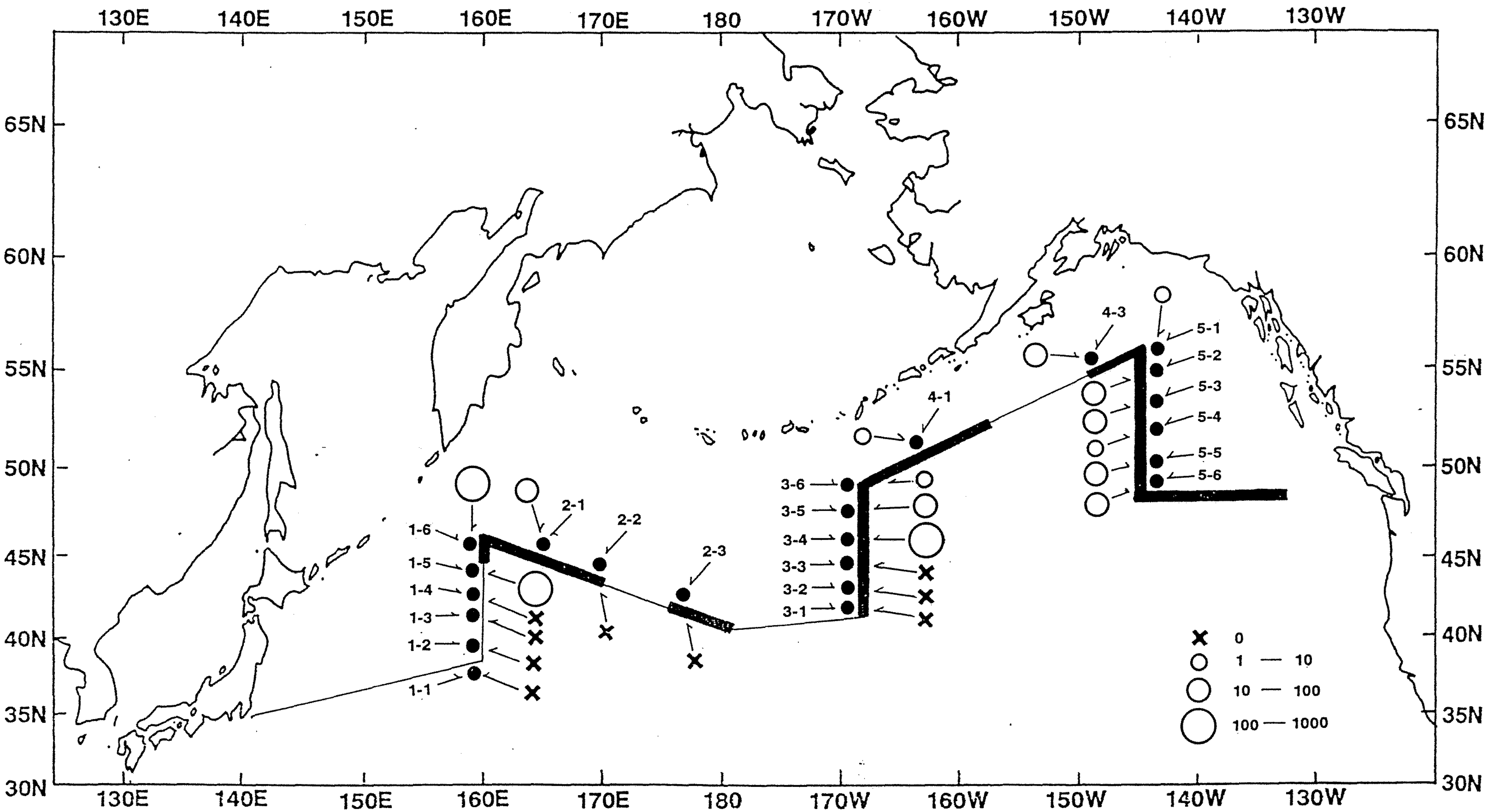

Figure 1. The area of the survey. The thin line indicates the line of the research vessel, the bold line the section of acoustic survey. Symbols like ○ or × show the stations of trawl net survey, the numbers connected with hyphen are the station number, and diameters of circles mean the catch of salmon per 60 minutes in number of individuals.

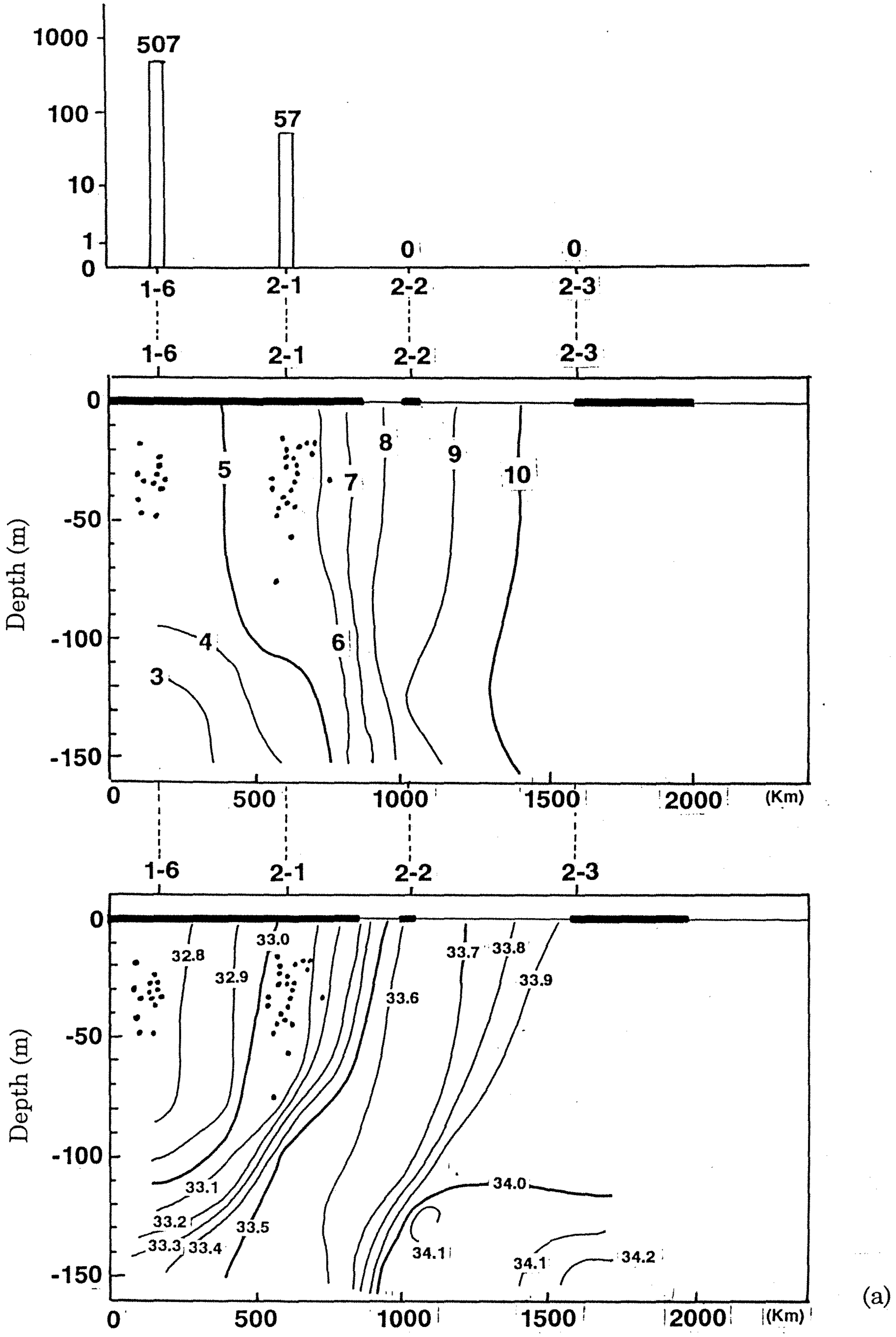

Figure 2. Catch of salmon in number at the station of trawl net survey (top), the responses from individual salmon superimposed to the distribution map of water temperature in ℃ (center) and salinity (bottom). The bold line drawn in the top of middle and bottom figure indicated the section in which we made acoustic survey. The maps divided in the western North Pacific (a), the central (b), and the eastern (c).

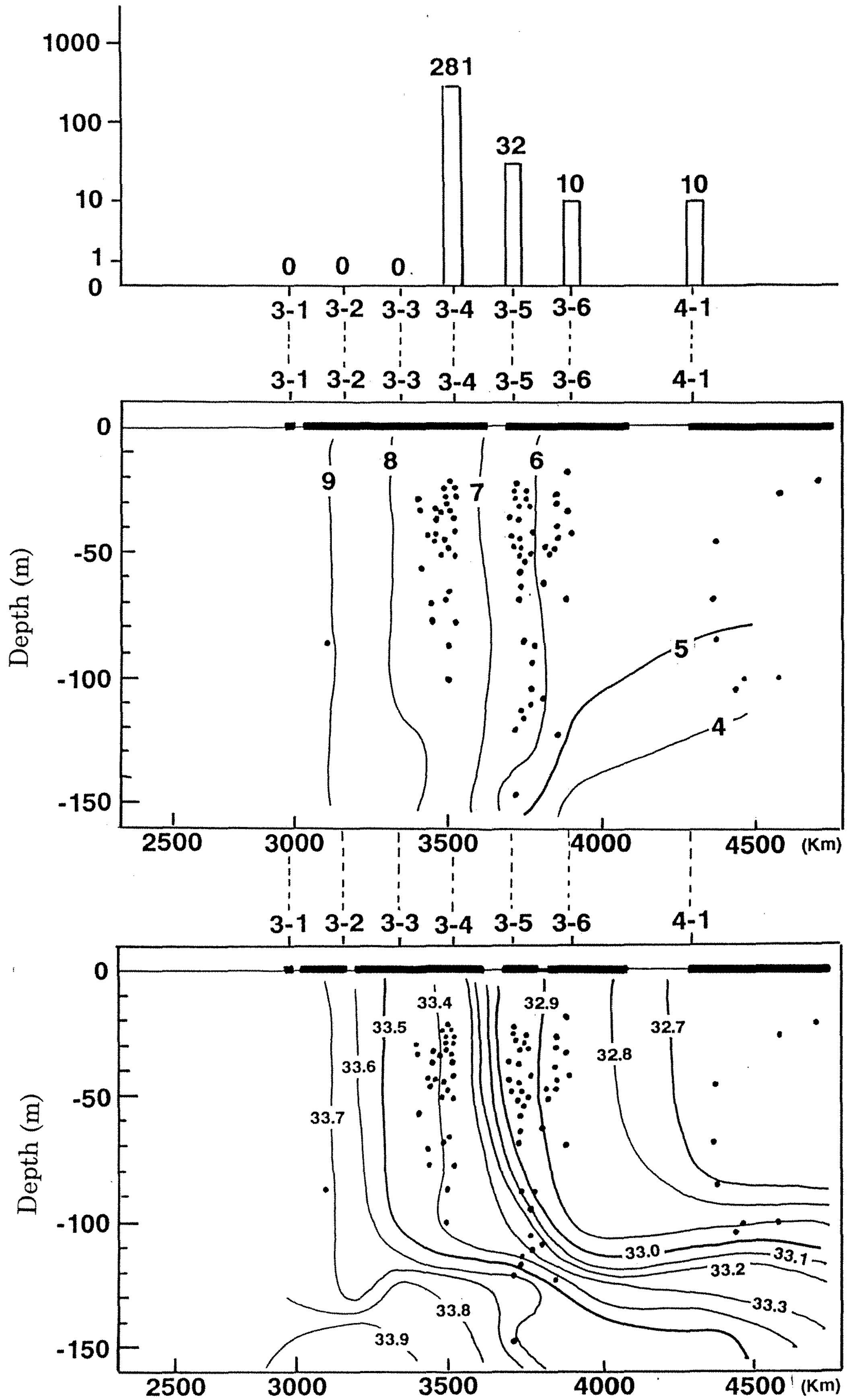
1000
100
10
1
0
281
32
10
10
0
0
0
3-1
3-2
3-3
3-4
3-5
3-6
4-1
Depth (m)
0
-50
-100
-150
9
8
7
6
5
4
2500
3000
3500
4000
4500
(Km)
33.4
33.5
33.6
33.7
33.8
33.9
32.9
32.8
32.7
33.0
33.1
33.2
33.3

Figure 2 (b)

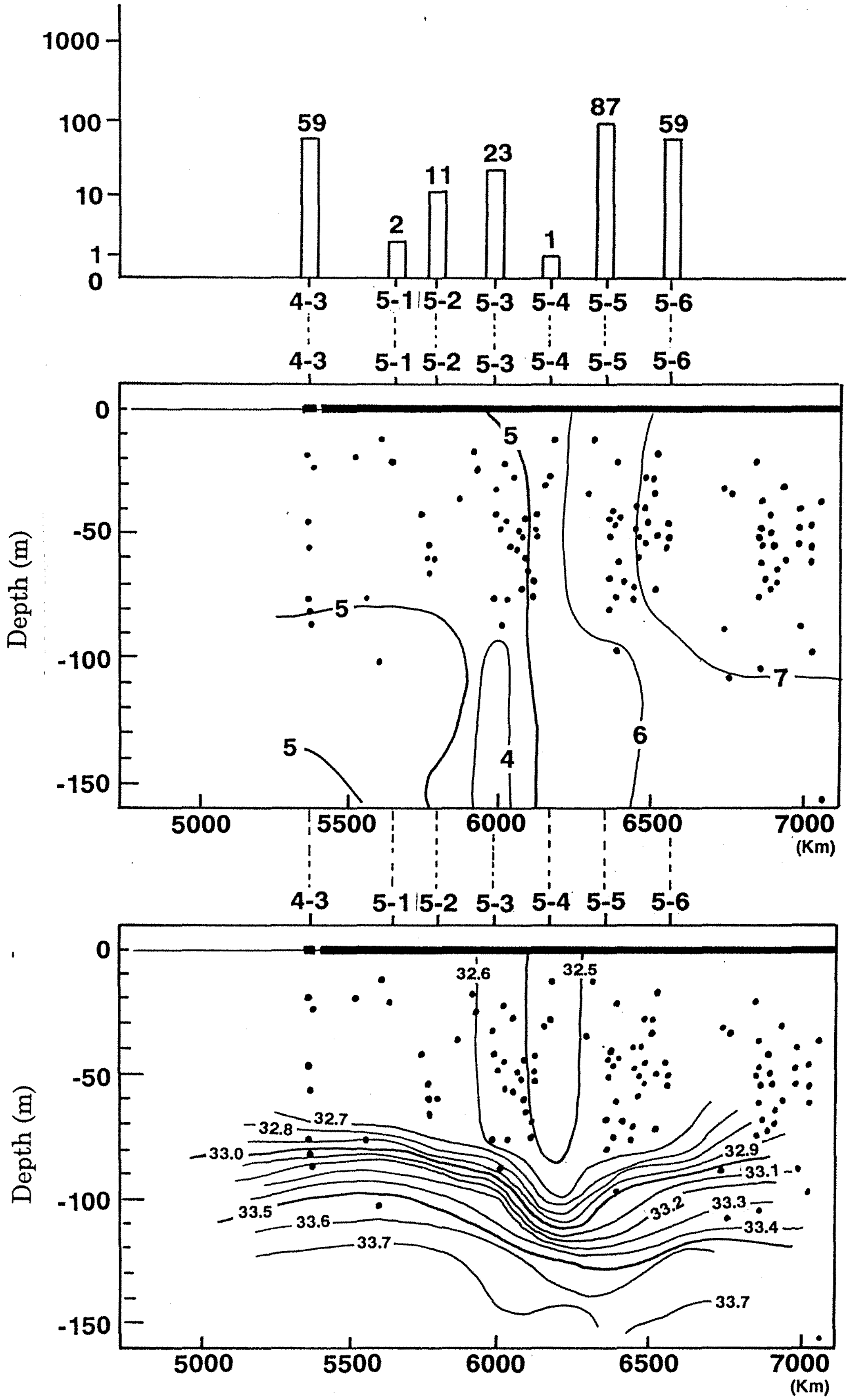
1000
100
10
1
0
59
2
11
23
1
87
59
4-3
5-1
5-2
5-3
5-4
5-5
5-6
Depth (m)
0
-50
-100
-150
5
5
5
4
6
7
5000
5500
6000
6500
7000
(Km)
32.6
32.5
32.7
32.8
33.0
32.9
33.1
33.2
33.3
33.4
33.5
33.6
33.7
33.7

Figure 2 (c)

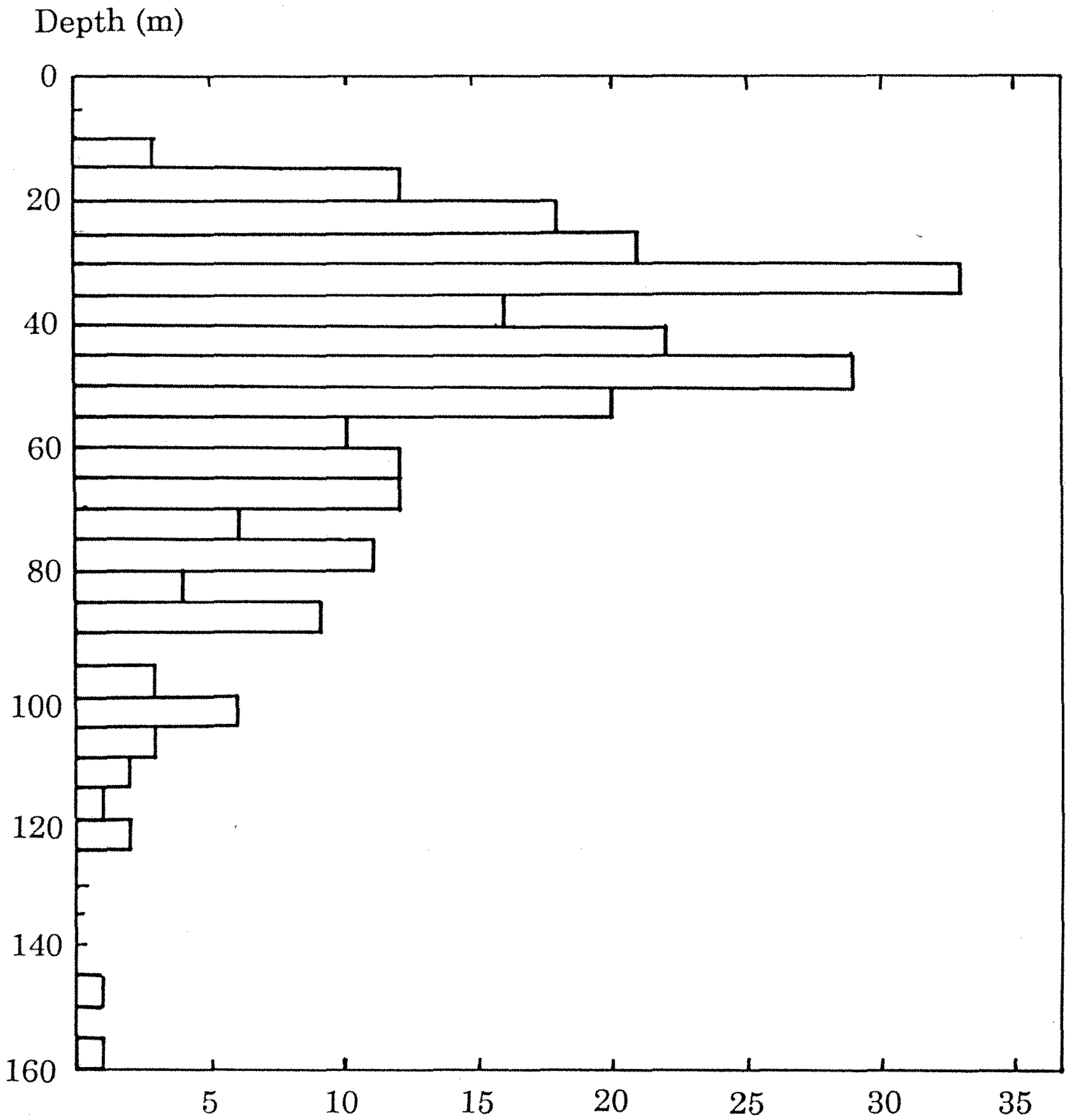

Figure 3. The number of salmon detected with echo sounder in each section of depth by 5 meters. All 257 salmon and both data in the daytime and nighttime are included here.

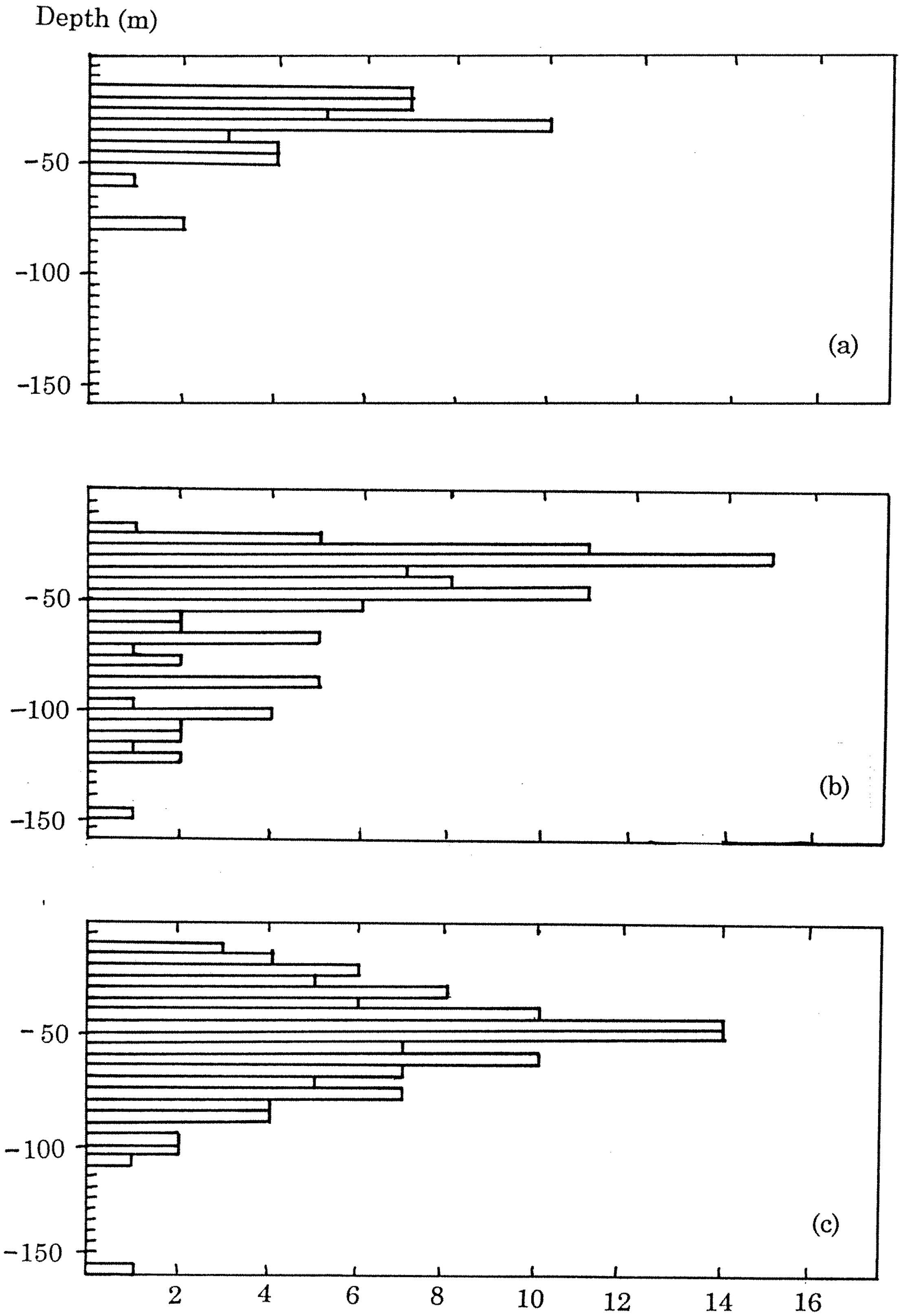

Figure 4. The number of salmon detected in each section of depth. The data are divided according to three survey areas, the western Pacific Ocean (a), the central (b), and the eastern (c).

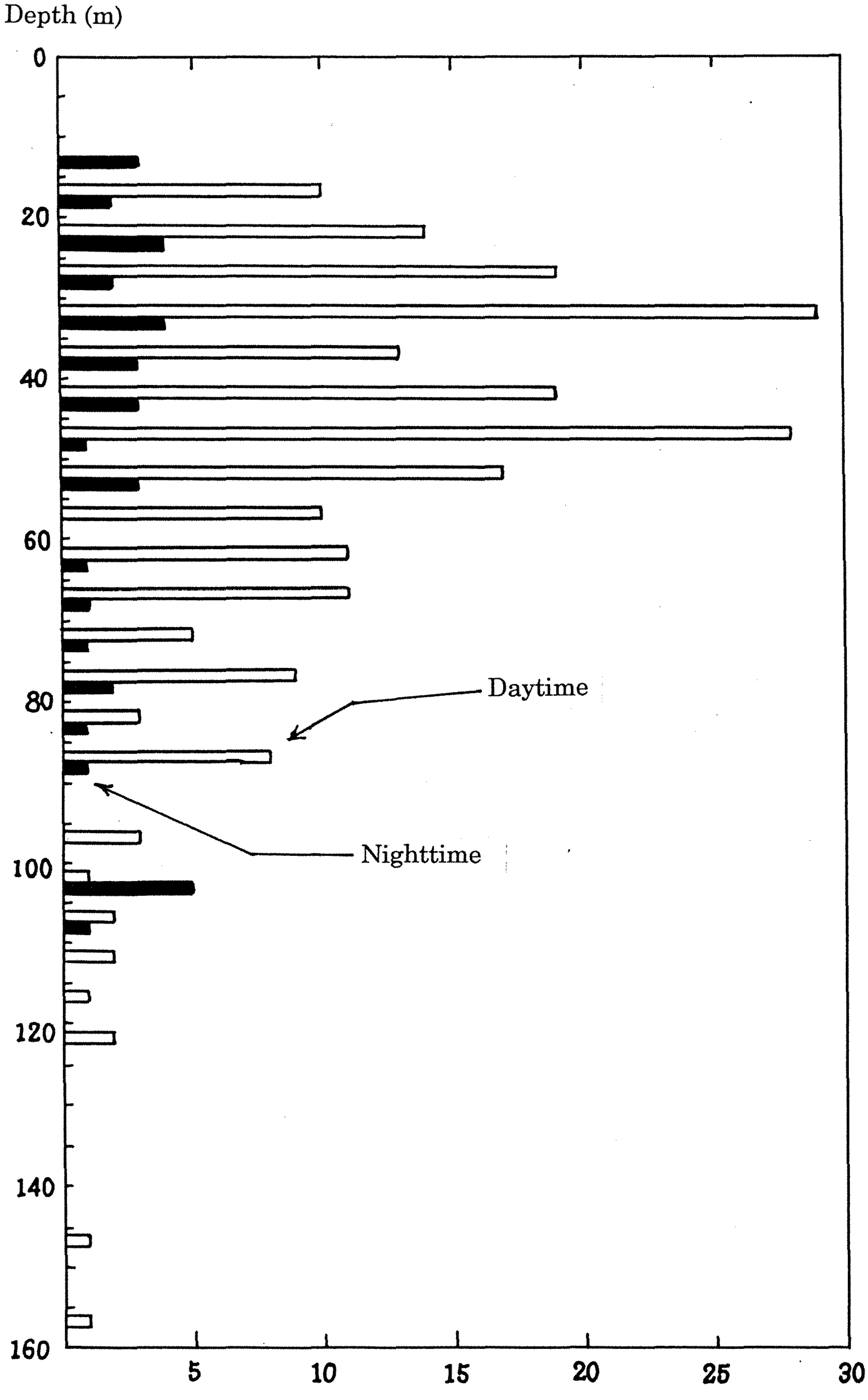

Figure 5. The differrence of the distribution of number of salmon detected by depth in the daytime and in the nighttime.