It seems that the habitat of salmon in the ocean is quite varied, depending on their age and species. Therefore, naturally it is expected that their vertical and horizontal distribution also depend on their age and species.

The research vessel Etsuzan-Maru conducted research on the vertical distribution of salmon in the Bering Sea and the northwestern North Pacific in 1961, in order to solve these ecological problems.

The Etsuzan-Maru left Hakodate Port on May 11 and returned on August 24. During her cruise, she conducted investigations at four points: one in late June in the Bering Sea during the first cruise; during the second cruise, at two points in the northwestern North Pacific in early and during mid-August, and at one point in the Bering Sea.

As this research was preliminary, these stations were not chosen for any special purpose but were set in areas where past experience suggested that salmon were rather abundant and oceanographic conditions were favorable. These stations are shown in Fig. 1.

**Gear and methods used**

Half of the floats were removed from the North Pacific standard salmon gillnets to allow their use as midwater gillnets. As the average weight of one shackle of this kind of net was 2.2 kg in the water, it was not necessary to add any extra weight other than the regular stone weighing 1 kg, which is usually attached to the driftnet. The nets were suspended from glass buoys about 30 cm in diameter, using ropes 40 m long. The depth at which the nets were set was adjusted by changing the length of the rope. At first, the nets were suspended at the ends of each tan, but later one more rope was added at the center of each tan of the nets in order to hold the net horizontally.

On the first day of operation at a station, the surface drift gillnet (INPFC standard nets and semi-commercial nets with 60.5 mm, and 65.0 mm, meshes) were used. Surface catches by 24 shackles or 4 sets of standard nets (12 shackles of 4 1/2 inch nets, 4 shackles each of 2 1/2, 3 1/4 and 5 1/4 inches) were recorded. On the second day, 12 sets of standard gillnets were connected by ropes and set at two different depth zones in midwater, i.e. one
one set around 10 - 16 m, and another at 20 - 26 m. On the third day, one set
was set at 30 - 36 m, depth and the other at 40 - 46 m, depth, in the same way
as those set on the second day. This three-day operation completed one opera-
tion at one station.

Here it should be understood that the abovementioned procedures were in
principle and that actually the order of operation was often changed. Also
sometimes the nets at 10 - 16 m, layers and at 20 - 26 m, layers were set at
the same time as the surface gillnets. The operations were conducted only at
night.

SUMMARY OF THE RESULTS OF THE RESEARCH

1. Catches

The numbers of salmon caught by the surface gillnets as well as by mid-
water gillnets are shown in Table 1. A total of 28 salmon were caught by
midwater drift gillnets (5 reds, 17 chums, 4 pinks, 2 kings and no silvers).

2. Depth of the catch

At the station occupied in June, red and pink salmon were caught between
the surface and a depth of 36 m., while chum and king salmon were caught
above 26 m.

At the stations occupied in August, red salmon were caught above 16 m.
from the surface, chum salmon were caught above 26 m, from the surface and
no other species of salmon were caught by midwater drift gillnets.

3. Water temperature and vertical distribution of salmon

The relationship between the vertical distribution patterns and the water
temperature at that time and place is illustrated in Fig. 2. At Station I in
the Bering Sea, which was covered in late June, the spring layer had not yet
been formed. Therefore, the gradual change with depth of water temperature
permitted distribution of all species of salmon down to rather deep waters.

But in August, at all the stations occupied, a marked spring layer had
been developed at from 15 m. to 40 m, below the surface, and salmon were
catched only above this spring layer.

4. Age and maturity

Out of 5 red salmon caught by midwater drift gillnets, one was 52 years,
2 were 51, and 2 were unidentified. All the fish of age 52 and 51 were caught
at Station I. The fish of age 53 seemed to be immature while those of 52
seemed to be mature salmon.

The age composition of chum salmon caught by the midwater drift gillnets
is shown in Table 2. All chum salmon (6 fish caught at Station I and Station
II) were 4 or 5-year old fish and seemed to be mature salmon, 10 chum salmon
captured at Station IV were 2 or 3 years old and all seemed immature. The
standard of identification of maturity established by R. Ishida and Takagi
was applied for determining the maturity of salmon.
5. **Number of salmon caught by gillnets of different mesh size**

The number of salmon caught by midwater salmon gillnets is shown in Table 3 for nets of each mesh size. 24 out of the 28 salmon caught were taken by 4 1/2 and 5 1/4 inch mesh nets and only 4 were taken by 2 1/2 and 3 1/4 inch mesh nets. These catches by smaller mesh nets were only made at Station IV. Station IV was located in an area where small-sized immature salmon (F.L. 30 - 40 cm.) are rather abundant every year, according to the results of experimental fishing by scientific research vessels.

**SUMMARY**

To summarize all the results obtained by the research in 1961, it seems that a fairly good number of salmon were present below the layer where commercial fishing operations are conducted, and this tendency seemed especially marked for chum salmon.

Also the horizontal distribution of salmon seemed to be somewhat related to the phase of vertical distribution of water temperature. Therefore, in the early season when the spring layer had not yet developed, salmon were rather dispersed and distributed to fairly deep layers. However, as the season progressed and the spring layer was formed, salmon were apt to be concentrated above the upper part of the spring layer.

It is also assumed that the pattern of the vertical distribution depends on the species as well as on their maturity. But, as research this year did not go further than a preliminary stage, and as the operations were on a rather small scale, using a limited quantity of gear, those problems were left to be solved in the future. Also, the operations were only at night. The vertical distribution pattern of salmon during the daytime was not studied at all.
TABLE 1. SALMON CATCHES BY ETSUZAN MARU, 1961

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Fishing station</th>
<th>Fishing depth (m)</th>
<th>Fishing time (hr. min.)</th>
<th>No. of nets used (shadex)</th>
<th>Surface Net</th>
<th>Sunken Net</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Latitude Longitude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-0</td>
<td>22.6</td>
<td>56°00'N 177°30'E</td>
<td>0-6</td>
<td>10.42</td>
<td>24</td>
<td>33 19 26</td>
<td>0 0</td>
<td>78</td>
</tr>
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<td>I-1</td>
<td>23.6</td>
<td>56°00'N 177°30'E</td>
<td>10-16</td>
<td>10.51</td>
<td>6</td>
<td>1 2 3 0</td>
<td>0 0 2</td>
<td>6</td>
</tr>
<tr>
<td>I-2</td>
<td>23.6</td>
<td>56°15'N 177°30'E</td>
<td>20-26</td>
<td>10.51</td>
<td>6</td>
<td>0 1 0 0</td>
<td>2 0 3</td>
<td>3</td>
</tr>
<tr>
<td>I-3</td>
<td>24.6</td>
<td>56°30'N 177°30'E</td>
<td>30-36</td>
<td>10.39</td>
<td>6</td>
<td>2 0 1 0</td>
<td>2 0 2</td>
<td>3</td>
</tr>
<tr>
<td>I-4</td>
<td>24.6</td>
<td>56°45'N 177°30'E</td>
<td>40-46</td>
<td>10.39</td>
<td>6</td>
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<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>II-0</td>
<td>4.8</td>
<td>51°00'N 164°30'E</td>
<td>0-6</td>
<td>10.35</td>
<td>24</td>
<td>26 30 0 17 1</td>
<td>0 0 0 20</td>
<td>74</td>
</tr>
<tr>
<td>II-1</td>
<td>2.8</td>
<td>51°00'N 164°00'E</td>
<td>10-16</td>
<td>11.08</td>
<td>6</td>
<td>0 3 0 0</td>
<td>0 0 0</td>
<td>3</td>
</tr>
<tr>
<td>II-2</td>
<td>2.8</td>
<td>51°00'N 164°00'E</td>
<td>20-26</td>
<td>11.08</td>
<td>6</td>
<td>0 0 0 0</td>
<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>II-3</td>
<td>3.8</td>
<td>51°00'N 164°00'E</td>
<td>30-36</td>
<td>11.05</td>
<td>6</td>
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<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>II-4</td>
<td>3.8</td>
<td>51°00'N 164°00'E</td>
<td>40-46</td>
<td>11.05</td>
<td>6</td>
<td>0 0 0 0</td>
<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>III-0</td>
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<td>52°00'N 166°32'E</td>
<td>0-6</td>
<td>10.30</td>
<td>24</td>
<td>58 14 0 13 1</td>
<td>0 0 0 0 20</td>
<td>86</td>
</tr>
<tr>
<td>III-1</td>
<td>6.8</td>
<td>52°30'N 166°32'E</td>
<td>10-16</td>
<td>10.30</td>
<td>6</td>
<td>1 1 0 0</td>
<td>0 0 0</td>
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<tr>
<td>III-2</td>
<td>6.8</td>
<td>52°30'N 166°32'E</td>
<td>20-26</td>
<td>10.30</td>
<td>6</td>
<td>0 0 0 0</td>
<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>IV-0</td>
<td>12.8</td>
<td>57°00'N 166°30'E</td>
<td>0-6</td>
<td>10.44</td>
<td>24</td>
<td>55 8 0 3 0</td>
<td>0 0 0 0 10</td>
<td>66</td>
</tr>
<tr>
<td>IV-1</td>
<td>13.8</td>
<td>57°00'N 166°30'E</td>
<td>10-16</td>
<td>10.37</td>
<td>6</td>
<td>1 9 0 0</td>
<td>0 0 1</td>
<td>10</td>
</tr>
<tr>
<td>IV-2</td>
<td>13.8</td>
<td>57°00'N 166°30'E</td>
<td>20-26</td>
<td>10.37</td>
<td>6</td>
<td>0 1 0 0</td>
<td>0 0 0</td>
<td>1</td>
</tr>
<tr>
<td>IV-3</td>
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<td>57°00'N 166°30'E</td>
<td>30-36</td>
<td>10.49</td>
<td>6</td>
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<td>0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>IV-4</td>
<td>14.8</td>
<td>57°15'N 166°30'E</td>
<td>40-46</td>
<td>10.49</td>
<td>6</td>
<td>0 0 0 0</td>
<td>0 0 0</td>
<td>0</td>
</tr>
</tbody>
</table>

TOTAL |       | 172 71 26 33 2 | 5 17 4 0 2 304 28

Note 1: I, II, III and IV - stations numbers. 0, 1, 2, 3, 4 - depth layers fished.

2. Catches by surface nets are made by 4 sets of INPFC standard gillnets; and catches by sunken nets are made by one set of INPFC standard gillnets modified for fishing at subsurface layers.
Table 2. The age composition of chum salmon caught by sunken net.

<table>
<thead>
<tr>
<th>Age St.</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>III</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>1</td>
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<tr>
<td>IV</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>17</td>
</tr>
</tbody>
</table>
Figure 1. Location of stations where studies of the vertical distribution of salmon were carried out by Etsuzan-maru in 1961.
Figure 2. Average temperature profiles (dotted lines) at each fishing station with salmon catches (surface catches were weighted to one set of the INPFC gillnets) at various depths.

<table>
<thead>
<tr>
<th>Station</th>
<th>Temperature Profiles (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station I</td>
<td>8.3 4.6 6.5 0 0</td>
</tr>
<tr>
<td>Station II</td>
<td>1 2 3 0 0 0 3 0 0 0</td>
</tr>
<tr>
<td>Station III</td>
<td>0 1 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Station IV</td>
<td>0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

**Legend:**
- **5°C** and **10°C** indicate temperature ranges.
- **Stn. I**, **Stn. II**, **Stn. III**, and **Stn. IV** represent different fishing stations.
1961年10月

北水研函館支所  柴鳥精治
海洋におけるサケマスの生活は魚種や発育段階によって異なる様相を呈し時期によって水平的または垂直的分布の状態を異なると思われる。これ等の生態学的調査問題を解明する研究の一環として昭和61年調査船越山丸によって北西太平洋及びベーリング海で行った垂直分布調査の概要を報告する。

越山丸は9月21日出港し8月26日帰港した。その間歩留次航海6月下旬ベーリング海で1回次航海8月上旬に北西太平洋で1回ベーリング海で1回計2回にわたりサケマスの垂直分布を調査した。本年度は予想的調査であった為調査点を特定の目的をもって選定したものではなく過去の知識から海洋条件が好ましく比較的魚の豊富であると思われる水域を撮った。これ等の調査点はFig.1に示した。

- 使用漁具及び調査方法
- 北太平洋標準流網の深さの数を半分に減らして垂直分布調査用中層流網とし、この操作によって網/及の水中重力が各種網平均して3.5kgとなった為、表層流網と同様/及び毎に約15kmの枠からとづけたはかには特別の沈降力は加えなかった。この中層流網を直径80cm/(1尺)のガラス玉に結び長さ40mの綱によって吊るし吊網の長さを適当に調節することに
よって所定の水層に施網した。最初前徹
はノ及々に給付したが、後水中での網を出
来るだけ水平に保つとそれ等の中間に更
にもうノ本の吊網を加えた。
調査方法はオノ目日に表層流網（I.N.
P.F.C標準網、60×60mm並びに60×30mm準商業網）
を設網しての中I.N.P.F.C標準流網セット
分メタ（メタ網合の網及又、3/4, 5/6
メタ網合の網各メタ）の漁獲数を表層
漁獲枚数として利用した。オメ目目は10
16m層流網セッ（メタ網合の網
及、3/4, 5/6メタ網合の網各メタ）
と20-26m層流網（10-16m層
層流網と同じ構成）を組で連ぎメタ
に施網した。オメ目目はオメ目目
の施網と同様の方法でメタ層
及び40-66m層の数分布の調査を終了し
た。上記の手順を変えて、上施網
の順に原則として下施網及び20-26m層
層流網とより後に連続して操
業した場合もあった。調査は前項の如く
行われた。
調査結果の概要
1. 漁獲枚数
大々の調査に於ける表層流網及び
中層流網の漁獲枚数をその附帯資料をTable
1に示した。中層流網による漁獲枚数は
メタ気でその内訳はメタカケタ、シロカケ
タ、カラフトマスメタ、マスメタ及びキ
ンサカの漁獲はなかった。
（以下）
マサウリを捕獲したまま、調査船を停泊させた。
そこで、深層水采水探査を行われた。
この時、観察していたのは、マサウリの
採水と採水された魚の種類と数だった。

調査結果から、深層水に含まれる魚種
が特定された。特に、マサウリに含まれ
る魚種のうち、深層水にしか見られない
種類が多数いた。

この結果は、マサウリの生態に、深層水
に限っては、特殊な魚種が含まれている
ことを示している。

さらに、マサウリの漁獲に際しては、
深層水に限っては、特定の種類の魚が
多く含まれていることが分かった。

これらの結果は、マサウリ漁業の
持続可能性に直接関連していると考え
られる。
1961年北西太平洋及びベーリング海で
行ったサケマス垂直分布調査概要

附図表
Figure 1: Location of stations where studies of the vertical distribution of salmon were carried out by Elsuzan-maru in 1961.
Figure 2: Average temperature profiles (dotted lines) at each fishing station with salmon catches (surface catches were weighted to one out of the I.M.P.F.C. gillnet) at various depths.
Table 1. Salmon catches by Estuary Name, 1961

<table>
<thead>
<tr>
<th>No</th>
<th>Date</th>
<th>Fishing station</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Fishing depth (in ft)</th>
<th>Number of sets used (5,400)</th>
<th>Surface net (tension)</th>
<th>Tension net (tension)</th>
<th>Total (tension)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>23.6</td>
<td>66-03N 177-30E</td>
<td>6 - 6</td>
<td>10.42</td>
<td>24</td>
<td>23.9, 26, 0, 0</td>
<td>1, 2, 3</td>
<td>0, 0</td>
<td>78</td>
</tr>
<tr>
<td>II</td>
<td>23.6</td>
<td>66-03N 177-30E</td>
<td>6 - 16</td>
<td>10.42</td>
<td>6</td>
<td>0, 0</td>
<td>0, 0</td>
<td>0, 0</td>
<td>6</td>
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<tr>
<td>III</td>
<td>23.6</td>
<td>66-03N 177-30E</td>
<td>10 - 16</td>
<td>10.42</td>
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<td>0, 0</td>
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<td>10.42</td>
<td>6</td>
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<td>0, 0</td>
<td>0, 0</td>
<td>8</td>
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<tr>
<td>V</td>
<td>23.6</td>
<td>66-03N 177-30E</td>
<td>30 - 36</td>
<td>10.42</td>
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<td>10.42</td>
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<td>10.42</td>
<td>24</td>
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<td>10 - 16</td>
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<td>8</td>
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<td>10.42</td>
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<td>0, 0</td>
<td>0, 0</td>
<td>8</td>
</tr>
</tbody>
</table>

Total: 171, 26, 23, 1, 171, 0, 0, 2, 300, 25

Note: 1. I, II, III, IV stations - numbers 0, 1, 2, 3, 4 = layers fished.
2. Catches by surface nets made by 5 sets of INPFC standard gillnets and codends. By number nets are made by one set of INPFC standard gillnets modified for fishing at submure layers.
Table 2. The age-composition of chum salmon caught by the anhogen net.

<table>
<thead>
<tr>
<th>Age</th>
<th>2</th>
<th>3</th>
<th>4</th>
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