INCIDENCE OF HALIBUT AND TANNER CRAB IN CATCHES BY THE EASTERN BERING SEA MOTHERSHIP TRAWL FISHERY AND INDEPENDENT TRAWLERS

by

Francis M. Fukuhara and Donald D. Worlund

Submitted to the
INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

by the U.S. NATIONAL SECTION

U.S. National Marine Fisheries Service
Northwest Fisheries Center
2725 Montlake Boulevard East
Seattle, Washington 98112
October 1973
Incidence of Halibut and Tanner Crab in Catches by the Eastern Bering Sea Mothership Trawl Fishery and Independent Trawlers

by

Francis M. Fukuhara and Donald D. Worlund

Beginning in March of 1973, at the invitation of the government of Japan, scientists and technicians of the United States and Canada (via the International Pacific Halibut Commission) were assigned to vessels of the Japanese eastern Bering Sea trawl fishery. The personnel and schedule of these assignments—as well as details of sampling procedure—are given in Document 1590.

The principle objectives of this activity were to obtain estimates of the incidence of halibut and crab in the landings of these fisheries. Information on the size, sex, age, and viability of these species was also obtained.

The following report summarizes some results to date and presents provisional estimates of the incidence of halibut and crab in trawl landings based upon information obtained through this program of biological observations.

The incidence of halibut is known to vary by season (INPFC Docs. 1319, 1410, 1502) and probably varies also with type of fishery or gear, area of operation and perhaps depth. Although there is little a priori information on the incidence of crab in catches of the trawl fishery (Doc. 1519), indications from the catches in trawl surveys clearly demonstrate their vulnerability to trawl gear (Doc. 1322, 1392, 1516). It is reasonable to expect that the sources of variation affecting the incidence of halibut in trawl catches also apply to the incidental capture of crab.
The purposes of this report are: (1) to assess these sources of variation inasmuch as they establish at least some criteria for determining the incidental catch of halibut and crabs; and (2) to estimate the number or tonnage of halibut or crab taken in the total annual catch of the eastern Bering Sea trawl fishery from incidences measured periodically and from samples obtained from selected vessels of a very large fleet.

Methods

Generally, scientific personnel assigned aboard motherships and stern trawlers used two basic sampling procedures.

For estimating the species composition of the landings, an attempt was made to randomly sample up to two tons of the catch per vessel per sampling per day. In practice, daily samples ranged from about 150 Kg to about 2 metric tons. Each sample was sorted and weight of catch determined by species. Each species sample was subsequently sub-sampled to obtain size, sex, and age information on selected species.

For stern trawlers, at times it was possible to obtain these samples from specific hauls. Aboard motherships, however, the samples were probably from a mixture of several hauls from a given gear type.

Due to the overwhelming bulk of the landings and the preponderance of pollock, the expectation of having even one halibut represented in the sample in the above procedure was very small. Although Tanner crab might have been sufficiently numerous to sample in this way, the incidence of both halibut and crab was estimated by an alternative sampling procedure.

Halibut and Tanner crab were sampled from a conveyor belt which unloaded the fish bin. The incidence of each species was calculated as a percentage of the estimated total weight of catch passing on the conveyor belt during the sampling period.
Fork length measurements to the nearest centimeter were obtained each day from 25-30 halibut. In most cases the sex of halibut was also determined. An average daily weight was obtained for halibut by dividing the total weight of the sampled halibut by the number of halibut in the sample.

Up to 150 crab per day were sexed, measured (to the nearest millimeter) and in some instances the shell condition and the occurrence of egg bearing females was also recorded. Average weight for crab was obtained daily by the same procedure described for halibut. In most cases, no species distinction was made between the two species of Tanner crab. King crab occurrence in the trawl-catches were so infrequent that no running record of their incidence was maintained.

Viability of halibut and crab was observed as the catch was brought aboard the factory ship (mothership or independent stern trawler) and later as they were dumped overboard through the trash chute.

Although the above generally describes the procedure for sampling, some variation in procedure was required to accommodate limitations imposed by practical work circumstances which were peculiar to particular motherships or independent trawlers.

RESULTS OF ESTIMATING THE INCIDENCES OF HALIBUT AND TANNER CRAB

Incidental Catch of Halibut and Crab

Halibut

The total catches sampled, the incidental catch of halibut, and their average size is summarized by time, gear type and MBL in Table 1.

The incidence of halibut in numbers per ton (no./ton) of total landings by gear type for the first through third quarters is given in Figures 1-3.

<table>
<thead>
<tr>
<th>Gear Type</th>
<th>MBL</th>
<th>QTR.</th>
<th>Inclusive Dates</th>
<th>Total Catch (mt)</th>
<th>2/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HALIBUT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No./Ton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(kg)</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>21</td>
<td>1</td>
<td>3/4 - 25</td>
<td>6376</td>
<td>5.590</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>21</td>
<td>1</td>
<td>3/10 - 31</td>
<td>6017</td>
<td>11.042</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>21</td>
<td>1</td>
<td>3/19 - 31</td>
<td>2198</td>
<td>2.209</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>21</td>
<td>2</td>
<td>4/1 - 7</td>
<td>1288</td>
<td>2.331</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>22</td>
<td>1</td>
<td>3/15 - 21</td>
<td>2898</td>
<td>2.071</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>22</td>
<td>1</td>
<td>3/16 - 3/30</td>
<td>7130</td>
<td>6.745</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>22</td>
<td>2</td>
<td>3/28 - 29</td>
<td>575</td>
<td>0.933</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>22</td>
<td>2</td>
<td>4/1</td>
<td>598</td>
<td>11.250</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>22</td>
<td>2</td>
<td>4/8</td>
<td>250</td>
<td>0.640</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>32</td>
<td>1</td>
<td>3/14 - 31</td>
<td>1101</td>
<td>0.733</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>32</td>
<td>2</td>
<td>6/28</td>
<td>241</td>
<td>2.543</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>32</td>
<td>2</td>
<td>4/1 - 25</td>
<td>6150</td>
<td>0.870</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>32</td>
<td>2</td>
<td>6/23 - 28</td>
<td>1047</td>
<td>0.146</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>32</td>
<td>3</td>
<td>7/1 - 6</td>
<td>4112</td>
<td>0.050</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>32</td>
<td>3</td>
<td>7/2 - 6</td>
<td>885</td>
<td>0.195</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>33</td>
<td>2</td>
<td>6/24 - 30</td>
<td>3986</td>
<td>0.160</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>33</td>
<td>2</td>
<td>6/25 - 30</td>
<td>1371</td>
<td>0.135</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>33</td>
<td>2</td>
<td>6/24 - 27</td>
<td>1950</td>
<td>0.076</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>33</td>
<td>2</td>
<td>6/24 - 9</td>
<td>927</td>
<td>0.212</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>33</td>
<td>3</td>
<td>7/7 - 7/8</td>
<td>2012</td>
<td>0.046</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>33</td>
<td>3</td>
<td>7/7</td>
<td>257</td>
<td>0.085</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>43</td>
<td>2</td>
<td>4/28 - 5/3</td>
<td>1750</td>
<td>0.024</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>43</td>
<td>3</td>
<td>7/9 - 11</td>
<td>2266</td>
<td>0.029</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>43</td>
<td>3</td>
<td>7/11</td>
<td>354</td>
<td></td>
</tr>
</tbody>
</table>

1/ Samples obtained from a mixture of gear types have been excluded.
2/ Weighted average incidence in no./ton (average of individual sample estimates weighted by the size of catch of daily or vessel landing sampled).
Figure 1. Incidence of halibut in numbers/ton of total catch by MEL, pair trawl (1), Danish seine (2), Dependent stern trawler (3), and Independent stern trawler (4).
Figure 2. Incidence of halibut in numbers/ton of total catch by MBL, pair trawl (1), Danish seine (2), Dependent stern trawler (3), and Independent stern trawler (4).
Figure 3. Incidence of halibut in numbers/ton of total catch by MBL, pair trawl (1), Danish seine (2), Dependent stern trawler (3), and Independent stern trawler (4).
The information base for the first quarter is incomplete inasmuch as it includes sampling in March only and excludes January and February. The third quarter excludes data from independent stern trawlers which has been collected but not organized for presentation at the time of this writing.

Several inferences are obtained from Figures 1-3 concerning the incidence of halibut.

1. The incidence of halibut is largest in MBLs 21, 22, and 32, all south of 57° 30' N and east of 175° W longitude (Figures 1 and 2).

2. The highest incidences in these blocks occur in the catches of the dependent stern trawlers attached to motherships (Figures 1 and 2).

3. In areas and at times when both the independent stern trawlers and other gear type(s) were sampled, the incidence of halibut was lower in the former (Figure 1 and 2) except in one case (Figure 2, MBL 32).

4. The incidence of halibut is the lowest in quarter III at least for the three quarters considered (Table 1 and Figures 1-3).

The seasonal trends as indicated by these data are in general agreement with earlier estimates reported by Japanese scientists in Docs. 1319 and 1410.

During spring (March 3-May 3) the highest incidence of halibut both in no./ton and as a percentage of the total catch in weight, as indicated from the incidence for each vessel day sampled, was from fishing in depths of 176-300 meters (Figures 4 and 5). At those depths fished by both mothership fleets and independent stern trawlers, the incidence of halibut was generally lower in the latter.

In summer (June 19-August 8) the catches of motherships with observers aboard were confined to waters shallower than 150 meters in depth. These catches had comparatively low incidences of halibut (Figures 4 and 5).
Figure 4.—Incidence of Halibut as Percentage of Total Sample Weight

- ○ Mothership — Spring
- ▲ Stern Trawler — Spring
- ● Mothership — Summer

PERCENTAGE BY WEIGHT

1.5
1.0
0.5
0.0

DEPTH (METERS)

100-125 126-150 151-175 176-200 201-225 226-250 251-275 276-300 301-325 326-350 351-375 > 375
Figure 5.—Incidence of Halibut/Metric Ton of Total Catch
The average weights of halibut from each vessel-day sampled in spring were slightly more variable (about 0.5 to about 3 Kg) at greater depths of fishing (say, deeper than 275 meters) with average weights in mothership landings generally less than the average weight of halibut in stern trawlers (Figure 6). In summer, more large halibut were encountered, increasing the variability of average lengths which ranged from 0.1 Kg to 10 Kg.

**Tanner Crab**

The incidence of Tanner crab was considerably higher than the incidence of halibut in both percentages of the total catch and the no./ton. The maximum incidence of Tanner crab in weight was over 12 percent of the total weight of the catch (Figure 7) and about 350 crab/metric ton (Figure 8).

In quarters I and II, the incidence of Tanner crab in independent stern trawler catches was consistently lower than that of other gear types (Table 2 and Figures 9-10). As noted in the discussion on halibut, for quarter III, information for stern trawlers was also collected but has not yet been prepared for inclusion in this report (Figure 11). The catches of Danish seines and pair trawlers (particularly the former) had the largest occurrence of Tanner crab (Figure 10, 11). The highest incidence of Tanner crab occurred in MBLs 21 and 22 in quarter I (Figure 9), MBLs 32 and 33 in quarter II and in MBLs 32 and 43 in quarter III (Figure 10 and 11). Danish seines had the highest average incidence of Tanner crab with 112 crab per metric ton in MBL 33 in quarter II and 131 crab per metric ton in MBL 32 in quarter III. Average incidence of Tanner crab in pair trawl catches ranged from about 20 crabs per metric ton to about 54 crabs per metric ton, with no obvious seasonal trend. The dependent stern trawlers which were highest in incidental catch of halibut had average incidences of
Figure 6.—Average Weight of Halibut by Depth
Figure 8.—Incidence of Tanner crab/Metric Ton of Total Catch

- Mothership — Spring
- Stern Trawler — Spring
- Mothership — Summer
Figure 7.--Incidence of Tanner crab as Percentage of Total Sample Weight
<table>
<thead>
<tr>
<th>Gear Type</th>
<th>MBL/</th>
<th>Quarter</th>
<th>Inclusive Dates</th>
<th>Total Catch (mt)</th>
<th>No/Ton/</th>
<th>Avg. Wt. (kg)</th>
<th>Avg. Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Pair Trawl</td>
<td>21</td>
<td>1</td>
<td>3/4-25</td>
<td>6376</td>
<td>19.662</td>
<td>0.428</td>
<td>100.43</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>21</td>
<td>1</td>
<td>3/10-31</td>
<td>6017</td>
<td>19.674</td>
<td>0.367</td>
<td>90.37</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>21</td>
<td>1</td>
<td>3/19-31</td>
<td>2198</td>
<td>1.331</td>
<td>0.539</td>
<td>107.70</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>21</td>
<td>2</td>
<td>4/1-7</td>
<td>1288</td>
<td>1.366</td>
<td>0.567</td>
<td>109.08</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>22</td>
<td>1</td>
<td>3/15-21</td>
<td>2898</td>
<td>54.427</td>
<td>0.628</td>
<td>105.51</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>22</td>
<td>1</td>
<td>3/16-30</td>
<td>7130</td>
<td>18.711</td>
<td>0.204</td>
<td>78.88</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>22</td>
<td>1</td>
<td>3/28-9</td>
<td>575</td>
<td>0.504</td>
<td>0.309</td>
<td>88.69</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>22</td>
<td>2</td>
<td>4/1</td>
<td>598</td>
<td>0.625</td>
<td>0.009</td>
<td>47.00</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>22</td>
<td>2</td>
<td>4/8</td>
<td>250</td>
<td>0.148</td>
<td>0.020</td>
<td>59.50</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>32</td>
<td>1</td>
<td>3/14-31</td>
<td>1101</td>
<td>1.425</td>
<td>0.208</td>
<td>71.44</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>32</td>
<td>2</td>
<td>6/32-8</td>
<td>1047</td>
<td>52.724</td>
<td>0.169</td>
<td>75.85</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>32</td>
<td>2</td>
<td>6/28</td>
<td>241</td>
<td>135.962</td>
<td>0.120</td>
<td>---</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>32</td>
<td>2</td>
<td>4/1-25</td>
<td>6150</td>
<td>1.152</td>
<td>0.214</td>
<td>75.62</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>32</td>
<td>3</td>
<td>7/1-6</td>
<td>4112</td>
<td>39.843</td>
<td>0.221</td>
<td>0.00</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>32</td>
<td>3</td>
<td>7/2-6</td>
<td>835</td>
<td>130.924</td>
<td>0.124</td>
<td>0.00</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>33</td>
<td>2</td>
<td>6/24-30</td>
<td>3986</td>
<td>49.323</td>
<td>0.357</td>
<td>64.89</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>33</td>
<td>2</td>
<td>6/25-30</td>
<td>1371</td>
<td>112.288</td>
<td>0.141</td>
<td>0.00</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>33</td>
<td>2</td>
<td>4/16-27</td>
<td>1950</td>
<td>0.604</td>
<td>0.219</td>
<td>89.60</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>33</td>
<td>2</td>
<td>6/24-29</td>
<td>927</td>
<td>34.407</td>
<td>0.115</td>
<td>117.74</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>33</td>
<td>3</td>
<td>7/7-8</td>
<td>2012</td>
<td>32.571</td>
<td>0.173</td>
<td>0.00</td>
</tr>
<tr>
<td>(3) Dep. St. Trawl</td>
<td>33</td>
<td>3</td>
<td>7/7</td>
<td>257</td>
<td>1.941</td>
<td>0.130</td>
<td>---</td>
</tr>
<tr>
<td>(4) Ind. St. Trawl</td>
<td>43</td>
<td>2</td>
<td>4/28-5/3</td>
<td>1750</td>
<td>1.034</td>
<td>0.164</td>
<td>68.47</td>
</tr>
<tr>
<td>(1) Pair Trawl</td>
<td>43</td>
<td>3</td>
<td>7/9-11</td>
<td>2266</td>
<td>43.380</td>
<td>0.435</td>
<td>0.00</td>
</tr>
<tr>
<td>(2) Danish Seine</td>
<td>43</td>
<td>3</td>
<td>7/11</td>
<td>354</td>
<td>37.700</td>
<td>0.219</td>
<td>---</td>
</tr>
</tbody>
</table>

1/ Samples obtained from a mixture of gear types have been excluded.

2/ Weighted average incidence in no./ton (average of individual sample estimates weighted by the size of catch of daily or vessel landings sampled).
Figure 9. Incidence of Tanner crab in numbers/ton of total catch by MBL, pair trawl (1), Danish seine (2), Dependent stern trawl (3), and Independent stern trawl (4).
Figure 10. Incidence of Tanner crab in numbers/ton of total catch by MBL, pair trawl (1), Danish seine (2), Dependent stern trawl (3), and Independent stern trawl (4).
Figure 11. Incidence of Tanner crab in numbers/ton of total catch by MBL, pair trawl (1), Danish seine (2), Dependent stern trawl (3), and Independent stern trawl (4).
Tanner crab ranging from about 0.6 to 34 crabs per ton of catch. Average incidence was lowest (0.15-1.42 crab/ton) in the catch of independent stern trawlers (Figure 9).

For the mothership fleets, the incidence of Tanner crab decreased in catches made in deeper waters (Figures 7 and 8). Although some Tanner crab were taken in depths to 350 meters, most were taken in waters shallower than 225 meters. The highest incidences of Tanner crab in mothership fleet catches occurred in depths of 150 meters or less.

The average weight of Tanner crab in the spring (Figure 12) was quite variable at most depths but with some indication of increase in average weight with increasing depth of fishing. The average size of Tanner crab taken in summer by the mothership fleets was uniformly small (generally less than 0.2 Kg).

Estimation of the Number of Halibut and Tanner Crab Taken by the Japanese Eastern Bering Sea Trawl Fishery.

From data presented in Documents 1410 and 1502, seasonal changes in the incidence of halibut were indicated. The above data confirms the occurrence of seasonal variation in the incidence of halibut. Moreover, there is evidence of substantial variability in the incidence of halibut between areas and among gear types. The same sources of variation pertain to the incidence of Tanner crab in trawl catches. The crab per ton of total catch was from 15 times (quarter I, MBL 21) to 108 times (quarter I, MBL 22) greater in Danish seine catches than in independent stern trawl landings (Figure 10).

Therefore, the best estimate of the total annual incidental catch of halibut and crab would be obtained by first applying the rate of incidence of halibut and crab (no./m.t.) to the corresponding total catch of each season-area-gear
Figure 12.—Average Weight of Tanner Crab by Depth

- Mothership - Spring
- Stern Trawler - Spring
- Mothership - Summer

Depth (Meters):
- 100-125
- 126-150
- 151-175
- 176-200
- 201-225
- 226-250
- 251-275
- 276-300
- 301-325
- 326-350
- 351-375
- >375

Average Weight (Kilograms):
- 0
- 0.2
- 0.4
- 0.6
- 0.8
- 1.0
stratum, than summing over the strata.

Such a procedure cannot be strictly followed at this time because (1) we have not completed observations in all quarters, (2) even for quarters sampled, data for some MBLs and gear types are unavailable and (3) catch records for the eastern Bering Sea trawl fishery for 1973 to which the estimated incidences should properly be applied are not yet available. For these reasons, calculation of the following estimates of the incidental catch of halibut and crab must carry some assumptions which are associated with the extrapolation of sample estimates of the incidence of halibut and crab in both time and space.

Apropos to the discussion of estimating the incidental catch of halibut by the eastern Bering Sea trawl fishery is an examination of information presented in Documents 1410 and 1502.

The rationale for the estimation procedure is included in five points defined on page 3 of the preliminary English translation of Document 1502. The reasoning for setting the incidental catch rate of halibut for the fish meal fleet in November and December at zero is not clear. Nor is it clear why the rate of halibut taken incidentally in relation to the quantity of yellowfin sole caught was used (rather than related to the total catch) for estimating the incidental catch of halibut for the freezer fleets for November, 1970 to February, 1971 and for meal fleets in January-February, 1971.

One might reason that the occurrence of halibut in trawl catches might be more likely related to the catch of yellowfin sole, however, this association has not been established. Furthermore, such an association would not discount the occurrence of halibut in significant numbers even in landings almost totally dominated by pollock as the data from other seasons clearly shows.
Sampling data from Document 1410 show pollock and yellowfin sole constituted from 78.0 to 90.2 percent of the November-February monthly landings (Table 3). These sample data generally indicate the percentage by weight of yellowfin sole to be considerably greater (72.3 to 86.6%) than the percentage by weight of pollock (2.7 to 6.2%) in the total catch.

The reported landings of the freezer fleets in the same months (however, for November, 1968-February, 1969) show yellowfin sole to be about 9.1 percent and pollock about 44.7 percent of the total catch in weight (Table 4). The catch of the freezer fleets was about 28 percent of the total landings of the combined catch by freezer fleets, meal fleets and independent trawlers. Pollock composed 61.4 percent and yellowfin sole only 3 percent of the landings of the combined fleets during the November to February time period (Table 5).

Given these disparities between the freezer fleet samples and the reported landings, it is obvious that the pair trawl samples do not adequately represent the relative dominance of pollock over yellowfin sole even in the catch of the freezer fleets aboard which sampling was done. How well such a sample reflects the incidence of halibut is problematic. On the basis of these data alone it seems no less rational and more straightforward to estimate the annual catch of halibut taken incidental to the trawl fishery by applying the monthly rates of incidence (relative to the total catch) to the total catch. By this procedure the tonnage of halibut caught incidentally by the eastern Bering Sea trawl fishery in November, 1968-October, 1969 is estimated to be 3,561 m.t. as opposed to 1,430 m.t. as estimated in Document 1502 and the number of incidentally caught halibut is about 4.59 million rather than 1.45 million as estimated in Document 1502 (Table 6).

<table>
<thead>
<tr>
<th>Month</th>
<th>Weight of Sample (kg)</th>
<th>Weight of Pollock (kg)</th>
<th>Weight of Yellowfin (kg)</th>
<th>% wt Pollock</th>
<th>% wt Yellowfin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov.</td>
<td>1183</td>
<td>32</td>
<td>963</td>
<td>2.7</td>
<td>81.4</td>
</tr>
<tr>
<td>Dec.</td>
<td>5752</td>
<td>358</td>
<td>4171</td>
<td>6.2</td>
<td>72.5</td>
</tr>
<tr>
<td>Jan.</td>
<td>5779</td>
<td>331</td>
<td>4179</td>
<td>5.7</td>
<td>72.3</td>
</tr>
<tr>
<td>Feb.</td>
<td>4110</td>
<td>150</td>
<td>3558</td>
<td>3.6</td>
<td>86.6</td>
</tr>
<tr>
<td>Total</td>
<td>16,824</td>
<td>871</td>
<td>12,871</td>
<td>5.2</td>
<td>76.5</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Month</th>
<th>Total Catch (mt)</th>
<th>Total Catch Pollock (mt)</th>
<th>Total Catch Yellowfin Sole (mt)</th>
<th>% Pollock</th>
<th>% Yellowfin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov.</td>
<td>11,404</td>
<td>6349</td>
<td>----</td>
<td>55.7</td>
<td>----</td>
</tr>
<tr>
<td>Dec.</td>
<td>11,892</td>
<td>4171</td>
<td>1505</td>
<td>35.1</td>
<td>12.6</td>
</tr>
<tr>
<td>Jan.</td>
<td>10,826</td>
<td>3809</td>
<td>1468</td>
<td>35.2</td>
<td>13.5</td>
</tr>
<tr>
<td>Feb.</td>
<td>9,761</td>
<td>5278</td>
<td>1023</td>
<td>54.1</td>
<td>10.5</td>
</tr>
<tr>
<td>Total</td>
<td>43,883</td>
<td>19,607</td>
<td>3996</td>
<td>45.7</td>
<td>9.3</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Fishery</th>
<th>Pollock mt</th>
<th>Pollock %</th>
<th>Yellowfin Sole mt</th>
<th>Yellowfin Sole %</th>
<th>Total mt</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meal</td>
<td>36,364</td>
<td>94.0</td>
<td>97</td>
<td>0.25</td>
<td>38,685</td>
<td>24.5</td>
</tr>
<tr>
<td>Freezing</td>
<td>19,607</td>
<td>44.7</td>
<td>3996</td>
<td>9.1</td>
<td>43,883</td>
<td>27.8</td>
</tr>
<tr>
<td>Independent Trawl</td>
<td>40,941</td>
<td>54.4</td>
<td>682</td>
<td>0.9</td>
<td>75,177</td>
<td>47.7</td>
</tr>
<tr>
<td>Total</td>
<td>96,912</td>
<td>61.4</td>
<td>4775</td>
<td>3.0</td>
<td>157,745</td>
<td>47.7</td>
</tr>
</tbody>
</table>
TABLE 6. Catch of Halibut in metric tons and numbers in 1968-69 by the Eastern Bering Sea trawl fishery as estimated from incidence of the total catch.

<table>
<thead>
<tr>
<th>Month</th>
<th>1/ Meal Freezing Fleet</th>
<th>1/ Indep. Trawlers</th>
<th>1/ Total Halibut</th>
<th>2/ Incid. of Halibut</th>
<th>Tons of Halibut</th>
<th>Avg. Wt. (kg)</th>
<th>No. of Halibut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov.</td>
<td>12,151 11,404</td>
<td>9,059 32,614</td>
<td>.00491</td>
<td>160</td>
<td>0.725</td>
<td>220,690</td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td>15,020 11,892</td>
<td>19,602 46,514</td>
<td>.02356</td>
<td>1096</td>
<td>0.852</td>
<td>1,286,385</td>
<td></td>
</tr>
<tr>
<td>Jan.</td>
<td>11,233 10,826</td>
<td>25,355 47,414</td>
<td>.00997</td>
<td>473</td>
<td>0.390</td>
<td>1,212,820</td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td>281 9,761</td>
<td>21,161 31,203</td>
<td>.00109</td>
<td>34</td>
<td>0.237</td>
<td>143,460</td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td>62,377 6,088</td>
<td>19,732 88,197</td>
<td>.00618</td>
<td>545</td>
<td>1.000</td>
<td>545,000</td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td>78,607 3,487</td>
<td>14,362 96,456</td>
<td>.00353</td>
<td>340</td>
<td>1.327</td>
<td>256,217</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>95,233 1,531</td>
<td>13,013 109,777</td>
<td>.00459</td>
<td>504</td>
<td>0.744</td>
<td>677,419</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>86,625 509</td>
<td>5,282 92,416</td>
<td>.00263</td>
<td>243</td>
<td>1.482</td>
<td>163,968</td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>145,948</td>
<td>17,281 163,229</td>
<td>.00000</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td>105,722</td>
<td>16,885 122,607</td>
<td>.00019</td>
<td>23</td>
<td>1.200</td>
<td>19,167</td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td>81,305</td>
<td>20,849 102,154</td>
<td>.00040</td>
<td>41</td>
<td>2.200</td>
<td>18,636</td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td>18,745 2,518</td>
<td>17,248 38,511</td>
<td>.00265</td>
<td>102</td>
<td>2.200</td>
<td>43,364</td>
<td></td>
</tr>
</tbody>
</table>

Total 713,247 58,016 199,829 971,092 3,561 4,587,126

---

1/ INPFC Doc. 1502 (Table 1.)
2/ INPFC Doc. 1319 & 1410
3/ Avg. of Sept. & Nov. incidence
4/ From INPFC Doc. 1410 & 1502
In the absence of 1973 catch statistics to which the observations obtained in 1973 are more strictly applicable, estimates of the incidental catch of halibut in 1971 were made using halibut incidence in catches of pair trawls, Danish seines, dependent stern trawlers and independent stern trawlers in 1973. Results are given in Table 7.

The average number of halibut per metric ton for gear 2 (Danish seines) in quarter I was estimated by the average of the ratios of the incidence in gear 2 to gear 1, gear 3 and gear 4 in quarters II and III. Likewise, the number of halibut per ton of catch for gear 4, quarter III was estimated by the average of the ratios of the incidence in gear 4 to gears 1, 2, and 3 in quarters I and II.

By applying the estimated incidence of halibut to corresponding total catches it is estimated that about 1,990,000 halibut were taken in the first three quarters of 1971. No attempt was made to estimate the incidental catch of halibut in the fourth quarter due to lack of observations in this quarter and the fact that estimates of the total incidental catch of halibut in 1971 are contained in other documents submitted to this meeting.

The procedure for estimating the number of Tanner crab taken in 1971 by pair trawls, Danish seines, dependent stern trawlers and independent stern trawlers in the eastern Bering Sea was the same as that used for estimating the incidental catch of halibut. Unlike the case for halibut, however, for Tanner crab there are no previous approximations of the annual catch. In estimating the incidental catch of crab in 1971, in the absence of observations in the fourth quarter of 1973, the incidence in quarter IV was assumed to be equal to that of quarter I.
TABLE 7. Estimate of Incidental Catch of Halibut taken by the Japanese Trawl Assevery (excluding side trawl and landbased dragnet) in the Eastern Bering Sea (E. of 180º) in 1971.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Gear</th>
<th>Total Catch (mt)</th>
<th>2/ (Avg.) (No./mt)</th>
<th>Est. No. of Halibut (1,000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>56,271</td>
<td>4.490</td>
<td>232.6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>37,548</td>
<td>(7.626)</td>
<td>286.3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>65,592</td>
<td>8.712</td>
<td>571.4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>99,989</td>
<td>1.600</td>
<td>160.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>259,400</td>
<td></td>
<td>1270.3</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>212,042</td>
<td>0.158</td>
<td>33.5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>162,148</td>
<td>0.496</td>
<td>80.4</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>98,657</td>
<td>4.541</td>
<td>448.0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>125,421</td>
<td>0.764</td>
<td>95.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>598,268</td>
<td></td>
<td>657.7</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>279,567</td>
<td>0.044</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>192,467</td>
<td>0.140</td>
<td>26.9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>48,706</td>
<td>0.085</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>163,409</td>
<td>(0.115)</td>
<td>18.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>684,149</td>
<td></td>
<td>62.1</td>
</tr>
<tr>
<td>Grand Total</td>
<td>1,541,817</td>
<td>1990.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ INFFC Doc. 1526

2/ As estimated by observations in 1973
Assuming that the incidence of Tanner crab in the catches of 1971 were not substantially different from estimates obtained for comparable periods in 1973, about 69,894,000 Tanner crab were taken incidentally in the first three quarters of 1971. The total incidental catch of Tanner crab in 1971 was about 70,890,000 Tanner crab (Table 8).

The estimated number of halibut and Tanner crab taken in the eastern Bering Sea in 1971 by pair trawls, Danish seines, dependent trawlers and independent trawlers is summarized in Table 9. Dependent trawlers associated with motherships are indicated to take substantially more halibut than any other gear type. Although pair trawlers were indicated to take more halibut than independent stern trawlers in the first quarter, in quarter II they took substantially less.

Most halibut (64% of the three quarter total) are indicated to have been taken in the first quarter. This may, however, be an underestimate since the first quarter observations in these analyses include only the month of March and exclude January during which the monthly incidence of halibut is indicated to be among the highest (Doc. 1410).

Pair trawls and Danish seines in particular are indicated to have the highest incidental catch of Tanner crab. The second and third quarters are estimated to account for about 90 percent of the total annual incidental catch of Tanner crab.

Viability of Halibut and Tanner Crab

It is the unanimous opinion of the scientists and technicians in observing the viability of halibut that most are dead upon return to the sea. The few that survive trawling and shipboard treatment are thought to be in weakened

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Gear</th>
<th>1/ Total Catch (mt)</th>
<th>2/ (Avg. No./Ton)</th>
<th>Est. No. of Crab (1,000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>56,271</td>
<td>30.526</td>
<td>1,718</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>37,548</td>
<td>(106.025)</td>
<td>3,981</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>65,592</td>
<td>19.152</td>
<td>1,256</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>99,989</td>
<td>1.235</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>259,400</td>
<td></td>
<td>7,078</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>212,042</td>
<td>50.031</td>
<td>10,609</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>162,148</td>
<td>115.828</td>
<td>18,781</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>98,657</td>
<td>21.161</td>
<td>2,088</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>125,421</td>
<td>1.043</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>598,268</td>
<td></td>
<td>31,609</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>279,567</td>
<td>39.055</td>
<td>10,918</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>192,467</td>
<td>104.289</td>
<td>20,072</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>48,706</td>
<td>1.941</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>163,409</td>
<td>(0.753)</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>684,149</td>
<td></td>
<td>31,207</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>9,396</td>
<td>30.526</td>
<td>287</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2,179</td>
<td>106.025</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>22,492</td>
<td>19.152</td>
<td>431</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>38,282</td>
<td>1.235</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72,349</td>
<td></td>
<td>996</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td>1,614,166</td>
<td></td>
<td>70,890</td>
</tr>
</tbody>
</table>

1/ IMPPC Doc. 1526
2/ As estimated by observations in 1973
3/ Average No./ton from Quarter 1
TABLE 9.--Estimated Number (in 1000s) of Halibut and Tanner Crab taken in E. Bering Sea in 1971 by Pair Trawl, Danish Seine, Dependent Stern Trawlers and Independent Stern Trawlers.

<table>
<thead>
<tr>
<th></th>
<th>Quarters</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td><strong>Halibut</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gear</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pair Trawl</strong></td>
<td>252.6</td>
<td>33.5</td>
<td>12.3</td>
<td></td>
<td>298.4</td>
<td></td>
</tr>
<tr>
<td><strong>Danish Seine</strong></td>
<td>286.3</td>
<td>80.4</td>
<td>26.9</td>
<td></td>
<td>393.6</td>
<td></td>
</tr>
<tr>
<td><strong>Dep. St. Trawl</strong></td>
<td>571.4</td>
<td>448.0</td>
<td>4.1</td>
<td></td>
<td>1,023.5</td>
<td></td>
</tr>
<tr>
<td><strong>Ind. St. Trawl</strong></td>
<td>160.0</td>
<td>95.8</td>
<td>18.8</td>
<td></td>
<td>274.6</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,270.3</td>
<td>657.7</td>
<td>62.1</td>
<td></td>
<td>1,990.1</td>
<td></td>
</tr>
</tbody>
</table>

| **Tanner Crab**     |                |        |        |        |        |        |
| **Pair Trawl**      | 1,718          | 10,609 | 10,918 | 287    | 23,532 |
| **Danish Seine**    | 3,981          | 18,781 | 20,072 | 231    | 43,065 |
| **Dep. St. Trawl**  | 1,256          | 2,088  | 94     | 431    | 3,869  |
| **Ind. St. Trawl**  | 123            | 131    | 123    | 47     | 424    |
| **Total**           | 7,078          | 31,609 | 31,207 | 996    | 70,890 |
condition and subject to predation by sea lions which occur in large numbers around the fishing operation.

Not all observers made estimates of the mortality to trawl caught Tanner crab. On the Yamato Maru (independent stern trawler) during the March to May period about 50 percent showed some signs of life when returned to the sea. Aboard the Ohtori Maru (ind. st. trawler) in June-August, it was estimated that 95 percent of the crab were dead due to time out of water, compression in the bins and damage from high pressure washers. Only when catches were small were crab returned immediately and alive to the sea.

During the March observations aboard the Gyokuei Maru (mothership) no estimates were made of the mortality to Tanner crab, however it was noted that on cold days (-8°C) crabs were glazed with ice within 10 minutes of unloading. In the August-September period on the Gyokuei Maru, due to the time between landing the evening catch and processing that catch which occurred about 10-11 a.m., 90 to 95 percent of the Tanner crab returned to the sea were considered to be dead. The overall mortality to Tanner crab for the period of observation was estimated to be 60-70 percent.

From these observations it would appear that the mortality to Tanner crab from the trawl fisheries is substantial.

Reports from courtesy boardings of vessels of the eastern Bering Sea trawl fishery by U.S. surveillance personnel indicate that very little attention is given to careful disposition of Tanner crabs aboard factory ships or factory trawlers. The prevailing impression of these U.S. surveillance personnel is that mortality to trawl caught crab is very high. Due to compression and
smothering in trawls and in fish bins and the impracticability of removing the numerous but very small Tanner crab from the fish bins and conveyor belts it is their view that very few crab survive (personal communication from Mr. Ronald Naab, Alaska Regional Enforcement Supervisor, NMFS). These are admittedly impressions, however, and no hard data are available on the survival of Tanner crab taken by the eastern Bering Sea trawl fishery.

CONCLUSIONS

Data obtained on the incidence of halibut and Tanner crab in 1973 by scientific observers did not cover all quarters or MBLs. In addition the 1973 eastern Bering Sea trawl fishery statistics to which the 1973 estimates of incidence are most applicable are not yet available. Therefore, the estimated incidental catches of halibut and crab presented in this report must be considered provisional.

Furthermore, additional analyses concerning sources of variation and the statistical distribution of the incidences of halibut and crab are necessary to derive the most appropriate estimation procedure.

It is possible, however, to derive some conclusions from the present analysis concerning the incidental catch of halibut and crab.

**Halibut**

1. Data obtained in 1973 confirms that the incidence of halibut is generally higher in the first quarter of the year and is minimal in the third quarter.

2. Differences among gear in the incidence of halibut are substantial and may indeed be as great as the seasonal differences in halibut incidence.
3. Incidence of halibut was greatest south of 57° 30' N latitude.

4. The incidental catch of halibut as reported in Document 1502 was recalculated by relating incidental catch of halibut to total catch rather than to the catch of yellowfin sole. This resulted in at least a twofold increase in the estimated catch of halibut in the November, 1968 to October, 1969 catch of the eastern Bering Sea trawl fishery.

5. The incidence of halibut by quarter and gear type as observed in 1973 was applied to the total catch by quarter and gear type of the 1971 eastern Bering Sea trawl fishery. An estimated 1,990,000 halibut were taken in the first three quarters of 1971. The estimated incidence of halibut, in the first quarter, however, did not include January or February, the former a month in which the incidence of halibut (0.997 percent of total catch in weight, Table 6) is exceeded only by the maximum incidence previously observed to occur in December (2.356 percent of total catch in weight).

Crab

1. King crab were so infrequent in the trawl catches observed that no systematic effort was made to record their incidence.

2. Incidence of Tanner crab in no./ton of total catch was considerably greater than the incidence of halibut.

3. There was evidence of substantial variation in the incidence of Tanner crab between seasons and particularly among gear types even within a given quarter and fishing area. The extent of variation attributable to the above sources was of sufficient magnitude to require estimating the total annual incidental catch by summing the estimated incidental catches for each quarter by gear type.
4. It was estimated that about 70,890,000 Tanner crab were caught incidentally by the trawl fishery in 1971, most of which were indicated to be taken in the second and third quarters by Danish seiners and pair trawlers.

RECOMMENDATIONS

1. The extent of the area is large and the variety of gear types sufficiently numerous so that time, area and gear coverage should be increased. We recommend that this be done not by increasing the effort of scientific observations but by extending the program of observations at the same level for an additional year.

2. Although the estimate of mortality of trawl caught halibut is thought to be reliable, there is a need to obtain better estimates of the mortality of Tanner crab caught by the trawl fisheries.

3. The incidental catch of Tanner crab should be identified as C. bairdi and C. opilio.

4. The impact to the eastern Bering Sea halibut and crab stock(s) in terms of loss in potential yield should be evaluated.