Vertical distribution of common squid (*Todarodes pacificus*) paralarvae in the northern East China Sea

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Cephalopods, especially common squid, is very important commercial species in Korea.

**WHY CEPHALOPOD LARVAE?**

Cephalopods, especially common squid, is very important commercial species in Korea.

**Catch proportion of the East Sea**

- **Others**: 43.2, 32.0, 33.5, 54.7, 54.7
- **Other pelagics**: 15.0, 12.7, 2.4, 4.0, 2.0
- **Horse mackerel**: 11.6, 8.3, 6.1, 4.0, 2.0
- **Saury**: 4.0, 8.3, 6.1, 4.0, 2.0
- **Sardine**: 6.1, 8.3, 6.1, 4.0, 2.0
- **Filefish**: 15.5, 15.5, 15.5, 15.5, 15.5
- **Walleye pollack**: 44.7, 33.5, 33.5, 33.5, 33.5
- **Common squid**: 20%
- **Common mackerel**: 0%
- **Anchovy**: 0%

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**Period**

- 1960s
- 1970s
- 1980s
- 1990s
- 2000s
WHY CEPHALOPOD LARVAE?

Cephalopods, especially common squid, is very important commercial species in Korea

Nobody interested in larval stage cephalopods

WHY DO WE STUDY VERTICAL DISTRIBUTION?

Key factor for dispersion of squid larvae from spawning place to feeding area

To track the movement by the Current

Influence recruitment  →  Recruitment variability
QUESTIONS AND PAST STUDIES

Changes in inferred spawning areas of *Todarodes pacificus* (Cephalopoda: Ommastrephidae) due to changing environmental conditions (Sakurai et al., 2000)

In common squid egg mass and larvae

- Egg mass stays above pycnocline, and hatching larvae swim up to surface.

(adapted from Sakurai et al., 2000)
PURPOSES

This Research aims to

1. Identify the distribution of cephalopod larvae near Jeju Island.

2. Figure out the relationship between water properties and larval occurrence of common squid.
MATERIALS AND METHODS

Sampling location

• Zooplankton sample using MOCNESS net
  • surface to bottom, with 20m depth interval
  • 333 mm mesh, 1x1.4m (1m²), 2-3 knot oblique tow
## MATERIALS AND METHODS

### Sampling cruise

<table>
<thead>
<tr>
<th>Cruise date</th>
<th>Number of Sample station (Larvae occurred St.)</th>
<th>Number of Sample bottle (1 bottle/20m depth)</th>
<th>Total number of larvae Occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 1997</td>
<td>15 (8)</td>
<td>133</td>
<td>66</td>
</tr>
<tr>
<td>Jan. 1999</td>
<td>21 (18)</td>
<td>136</td>
<td>172</td>
</tr>
<tr>
<td>Apr. 1999</td>
<td>18 (15)</td>
<td>112</td>
<td>235</td>
</tr>
<tr>
<td>Oct. 2000</td>
<td>11 (8)</td>
<td>52</td>
<td>193</td>
</tr>
</tbody>
</table>
**MATERIALS AND METHODS**

**Lab. work**

- Specimens:
  - **Sort and Identification** - cephalopod larvae
    - Morphological identification - under light microscope
    - Dorsal Mantle Length (ML, mm) measurement

- **Larval density at each depth interval**
  - Based on the number caught and the amount of water filtered

- **Water density**
  - Based on temperature and salinity at depth
  - Vertical profile of water density was overlap on larval density in water column.
MATERIALS AND METHODS

Ommastrephidae
Common squid, flying squid, *T. pacificus*

- Small fins, relatively short arms
- **Fused tentacle** (proboscis)
  - Rhynchoteuthion larvae, Paralarvae
  - 8 suckers on tentacle tip

Bobtail squid
Pencil squid
Enop. Squid
Octopod
## RESULTS

### VERTICAL DISTRIBUTION

Larval abundance and proportion

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>10</td>
<td>30</td>
<td>10</td>
<td>63</td>
<td>113</td>
<td>16.9</td>
</tr>
<tr>
<td>20-40</td>
<td>29</td>
<td>54</td>
<td>64</td>
<td>65</td>
<td>212</td>
<td>31.7</td>
</tr>
<tr>
<td>40-60</td>
<td>20</td>
<td>44</td>
<td>63</td>
<td>51</td>
<td>178</td>
<td>26.6</td>
</tr>
<tr>
<td>60-80</td>
<td>5</td>
<td>25</td>
<td>74</td>
<td>13</td>
<td>117</td>
<td>17.5</td>
</tr>
<tr>
<td>80-100</td>
<td>2</td>
<td>19</td>
<td>20</td>
<td>1</td>
<td>42</td>
<td>6.3</td>
</tr>
<tr>
<td>100-120</td>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>66</td>
<td>172</td>
<td>237</td>
<td>193</td>
<td>668</td>
<td>92.7%</td>
</tr>
</tbody>
</table>

92.7%

75.8%
RESULTS

VERTICAL DISTRIBUTION

Apr. 1999:
- T. Pacificus: 153 / 235 (65.11%)

Oct. 2000:
- T. Pacificus: 103 / 193 (53.37%)

Graphs showing the vertical distribution of T. Pacificus in April 1999 and October 2000, with depth categories from 10 to 110 meters and 10 to 90 meters, respectively.
**RESULT**

**VERTICAL DISTRIBUTION**

Vertical pattern of larval density

![Graph showing vertical pattern of larval density with depth vs. larval density (Ind./1000m³) for different months: Aug. '97, Oct. '00, Jan. '99, Apr. '99.](image)
RESULT

HIGH DENSITY IN UPPER 50 m

With stratified condition

**Aug. 1997**

- Seawater density (σ, kg/m³)
  - 19
  - 20
  - 21
  - 22
  - 23
  - 24
  - 25
  - 26
  - 27

- Larval density
  - 7.99
  - 13.3
  - 11.25
  - 7.82
  - 7.90

**Oct. 2000**

- Seawater density (σ, kg/m³)
  - 20
  - 21
  - 22
  - 23
  - 24
  - 25
  - 26
  - 27

- Larval density
  - 32.29
  - 27.27
  - 19.39
  - 3.12
RESULT

HIGH DENSITY IN MID LAYER

With well-mixed condition

Jan. 1999

Seawater density (σt, Kg/m³)

Larval density (ind./1000m³)

Apr. 1999

Seawater density (σt, kg/m³)

Larval density (ind./1000m³)

Mean density
Larval density
Mean density
RESULT.

LARVAL SIZE AND DEPTH

October 2000

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Total</th>
<th>T. pacificus</th>
<th>Mean ML</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>63</td>
<td>34</td>
<td>1.74</td>
<td>0.109</td>
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<td>20-40</td>
<td>65</td>
<td>37</td>
<td>2.10</td>
<td>0.192</td>
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<tr>
<td>40-60</td>
<td>51</td>
<td>30</td>
<td>2.43</td>
<td>0.151</td>
</tr>
<tr>
<td>60-80</td>
<td>13</td>
<td>2</td>
<td>3.43</td>
<td>0.425</td>
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<tr>
<td>80-100</td>
<td>1</td>
<td>0</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

193 total, 53.37%
RESULT 3.
LARVAL SIZE AND DEPTH

April 1999

<table>
<thead>
<tr>
<th>Depth</th>
<th>Total</th>
<th>T. pacificus</th>
<th>Mean ML</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>10</td>
<td>6</td>
<td>3.44</td>
<td>0.468</td>
</tr>
<tr>
<td>20-40</td>
<td>62</td>
<td>47</td>
<td>3.54</td>
<td>0.218</td>
</tr>
<tr>
<td>40-60</td>
<td>63</td>
<td>41</td>
<td>3.54</td>
<td>0.235</td>
</tr>
<tr>
<td>60-80</td>
<td>74</td>
<td>49</td>
<td>2.98</td>
<td>0.174</td>
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<tr>
<td>80-100</td>
<td>20</td>
<td>10</td>
<td>3.68</td>
<td>0.236</td>
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<tr>
<td>100-120</td>
<td>6</td>
<td>0</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>235</td>
<td>153</td>
<td>65.11%</td>
<td></td>
</tr>
</tbody>
</table>

Apr. 1999 Larvae Mantle Length
Bars are One Standard Error from the Mean

\[ y = -0.0067x + 3.7084 \]
\[ R^2 = 0.0107 \]
DISCUSSION

Vertical distribution of common squid (*Todarodes pacificus*) larvae near Japan (Yamamoto et al., 2007)

- Oki Island, Japan
  - primary spawning ground of Autumn spawning population
- Period: Nov. 1998-2002
- **MOCNESS**, 0.333mm, 25m depth
- 1,511 paralarvae
  - ML range: 0.7-7.3mm
- 84% paralarvae collected above 75m water depth and mixed layer
- Do not exhibit large vertical migration pattern
- Larvae increase in size with water depth

(Yamamoto et al., 2007)
DISCUSSION

Larvae size and depth - *Todarodes pacificus*

- Individual size and depth relationship (Yamamoto et al., 2007)
  - Gradually increase in size each depth interval
  - Similar environmental condition
    - thermocline exist around 75m water depth

After Yamamoto et al. (2007)

![Graph showing larval size and depth relationship](image)
DISCUSSION

Larvae size and depth - *Todarodes pacificus*

- But in this research
CONCLUSION

Stratified condition

• Higher larval density upper picnocline (or thermocline)

Well mixed condition

• Higher densities shown in mid layer

Sampling strategy

• Consider the seasonal variation of picnocline

Marine physics model

• Concern the current depth and high density larval depth
Thank you for your attention