INTRODUCTION

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1.1 Use of *Ichthyoplankton* Surveys for Fisheries Resources Research (modified Hempel 1973)

1. Studies in biology

2. Detection and Appraisal of Fishery Resources

3. Studies in Population Dynamics of Fishes


*Ichthyoplankton* = fish eggs and larvae
1. Studies in biology

1-1. Studying the identification and systematics

1-2. Studying the development, growth, behavior, food requirements and mortality of the early stages of economically important fishes as related to environmental factors

1-3. Providing a better understanding of oceanic biology, e.g., zoogeography and ecology of all organisms in the samples
Representative larvae of lophiiform fishes (Pietsch, 1984)

Proposed phylogenetic relationships of the major subgroups of the Lophiiformes based on the selected morphological features of larvae (Pietsch, 1984)

Current status of identification of fish eggs and larvae in the Southeast Asian region

- Very poor knowledge on identification of marine fish eggs and larvae in the Southeast Asia region
  The initiative study made for fish eggs and larvae from the Java Sea by Delsman (1921-1938) – very limited species; Chayakul (1996): the fish larvae in the Gulf of Thailand
- Family/genus level of larval identification in the region except some species
- Toward to species identification by larval morphology for commercially important fishes
  1) A series specimens from larval stage to juvenile stage
  2) Aid of DNA analysis
  3) Rearing

Delsman, H. C. 1921-1938: Fish eggs and larvae from the Java Sea. Treubia. 2, 3, 6, 8, 9, 11, 12, 13, 14 and 16.


Development of swimming & feeding function of fish larvae (1)

Development of the caudal complex in *Pagrus major* larvae. A: 5.10 mm NL; B: 5.45 mm NL; C: 6.40 mm NL; D: 7.95 mm NL; E: 10.15 mm NL. Ep: epural; Hs: haemal spine; Hy: hypurals; Ns: neural spine; Ph: parhypural; Uc: ural centra. Scale bars: 0.2 mm. (Kohno et al. 1983)

Caudal complex of a double-stained anchovy juvenile: cartilages (blue); bones (red) (Sumikawa and Fujita, 1984)

Development of the upper jaw in *Pagrus major* larvae. A: 3.70 mm NL; B: 5.45 mm NL; C: 6.50 mm NL; D: 7.95 mm NL; E: 10.15 mm NL. AHMx: articular head of maxilla; ArPPm: articular process of premaxilla; AsPPm: ascending process of premaxilla; Mx: maxilla; PMPPm: postmaxillary process of premaxilla. Scale bar: 0.2 mm. *(Kohno et al. 1983)*
Development of swimming & feeding function of fish larvae (3)

<table>
<thead>
<tr>
<th>Dorsal: fin-rays</th>
<th>5.90 (6.03)</th>
<th>6.50 (6.73)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal: fin-supports</td>
<td>5.05 (-)</td>
<td>6.00 (6.14)</td>
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<tr>
<td>Anal: fin-rays</td>
<td>5.90 (6.03)</td>
<td>6.50 (6.73)</td>
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<tr>
<td>Anal: fin-supports</td>
<td>5.05 (-)</td>
<td>5.70 (5.79)</td>
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<tr>
<td>Caudal: fin-rays</td>
<td>4.95 (-)</td>
<td>6.10 (6.26)</td>
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<tr>
<td>Caudal: fin-supports</td>
<td>4.40 (-)</td>
<td>ca 5.00 (-)</td>
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<tr>
<td>Pectoral: fin-rays</td>
<td>5.70 (5.79)</td>
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<tr>
<td>Pelvic: fin-rays</td>
<td>6.50 (6.73)</td>
<td>7.75 (8.21)</td>
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<tr>
<td>Pelvic: fin-supports</td>
<td>5.90 (6.03)</td>
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<tr>
<td>Greatest body depth/NL</td>
<td>ca 6.50 (6.73)</td>
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<tr>
<td>D. A.C separation</td>
<td>6.50 (6.73)</td>
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<tr>
<td>Notochord end flexion</td>
<td>ca 5.00 (-)</td>
<td>ca 6.50 (6.73)</td>
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### Mode of swimming

<table>
<thead>
<tr>
<th>NL (mm)</th>
<th>less active swimming</th>
<th>transitional stage</th>
<th>caudal propulsion</th>
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</table>

### Mode of feeding

<table>
<thead>
<tr>
<th>Mode of feeding</th>
<th>swallowing</th>
<th>transitional stage</th>
<th>biting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premaxillary teeth</td>
<td>4.40 (-)</td>
<td>ca 7.00 (7.32)</td>
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</tr>
<tr>
<td>Dentary teeth</td>
<td>4.95 (-)</td>
<td>ca 7.00 (7.32)</td>
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<tr>
<td>Up. pharyngeal teeth</td>
<td></td>
<td>ca 7.00 (7.32)</td>
<td></td>
</tr>
<tr>
<td>Low. pharyngeal teeth</td>
<td></td>
<td>ca 7.00 (7.32)</td>
<td></td>
</tr>
<tr>
<td>Premaxilla/gape</td>
<td>3.90 (-)</td>
<td>ca 7.00 (7.32)</td>
<td></td>
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</tbody>
</table>

(Kohno et al. 1983)
Early growth of sparid fish, *Pagrus major* by otolith increments (Tanaka, unpublished)
1-3) Understanding of oceanic biology

Distributions of SST and larvae of jack mackerel from 4-21 Feb., 2001 in the East China Sea (Sassa et al., 2006)

2. Detection and Appraisal of Fishery Resources

2-1. Exploring for new resources

2-2. Locating spawning concentration of important stocks

2-3. Describing relative abundance of commercially important stocks

2-4. Monitoring long-term changes in the composition and abundance of resources and spawning times and areas
2-1) Exploring for new resources

**Sampling gear**

- Larvae
- Adults

**Life mode**

- Larva net: Planktonic
- Scomber: Pelagic
- Croaker: Demersal
- Snapper: Coral reef

**Sampling gears**

- Mono-type sampling gear
- Multi-type sampling gears

- Purse seine
- Set net
- Bottom trawl
- Bottom gill net
- Gill net
- Trap
2-2) Locating spawning concentration of important stocks

Distribution and abundance of nemipterid (thread-fin bream fish) larvae in the South China Sea at post-monsoon season from 1995-1999

- Main spawning grounds
  - Tonkin Bay
  - Gulf of Thailand
  - Off Sarawaku
2-3) Describing relative abundance of commercially important stocks

2-4) Monitoring long-term changes (3-1 fluctuations in spawning stock) in the composition and abundance of resources

Three independent estimates of the stock of Pacific mackerel off Southern California and Baja California, Mexico (Smith and Richardson, 1977)

2-4) Monitoring long-term changes in the spawning area and time

Distribution of Japanese sardine (Sardinops melanostictus) eggs on the Pacific side of Japan. Solid line indicates the Kuroshio current route in the main spawning season. Solid circles show the annual egg abundance in 30' x 30' squares in trillions (Watanabe et al., 1995)

3. Studies in Population Dynamics of Fishes

3-1. Tracing fluctuations in spawning stocks by estimating the abundance of their eggs and young larvae

3-2. Forecasting year-class strength on the basis of the abundance of old larvae (juveniles)

3-3. Estimating abundance of a stock based on its spawning production

3-4. Discriminating between stocks of the same species
3-1. Estimation of abundance of spawning stocks by ichthyoplankton (egg) survey (1)

**Absolute abundance**
- Spawning stock size to be estimated based on a total number of spawned eggs by ichthyoplankton surveys, parameters of batch fecundity and spawning times for adult female, and sex ratio of adult fish

**Relative abundance**
- Spawning stock size to be calculated as a total number of eggs distributed in a sea area at the surveys
3-1. Estimation of abundance of spawning stocks by ichthyoplankton (egg) surveys (2)

**Absolute abundance** (exp. Japanese sardine)

1. \( E = \frac{e \times a \times D}{s \times d} \)
   - \( E \): number of eggs spawned in the sea in a month
   - \( e \): egg density per m\(^2\) of sea surface by net tow
   - \( a \): area (in m\(^2\)) of a sub-area (30’ x 30’ square)
   - \( D \): days in a month
   - \( s \): survival rate in egg stage
   - \( d \): days required by hatching

2. \( N_1 = \frac{E}{f \times t} \)
   - \( N_1 \): number of adult females
   - \( f \): batch fecundity (no of released eggs per spawning action)
   - \( t \): spawning frequency in a season

3. \( N_2 = \frac{N_1}{r} \)
   - \( N_2 \): number of adult fish
   - \( r \): sex ratio


3-1. Estimation of abundance of spawning stocks by ichthyoplankton (egg) surveys (3)

Excel table for calculation of number \((E)\) of eggs spawned in the sea in a month

<table>
<thead>
<tr>
<th>Month</th>
<th>Sub-area</th>
<th>No of eggs ((m^2))</th>
<th>Average number of eggs ((m^2))</th>
<th>Weighted SST by number of eggs</th>
<th>Required days by hatching</th>
<th>Days in a month</th>
<th>Survival rate of egg stage</th>
<th>Area of sub-sea area ((30'\text{ Lat} \times 30'\text{ Long}; 10^8 \text{ m}^2))</th>
<th>Estimated eggs spawned in a sub-area and a month ((10^12))</th>
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<tbody>
<tr>
<td>FEB</td>
<td>xxxx1</td>
<td>13.21</td>
<td>15.22</td>
<td>61.37</td>
<td>15.60</td>
<td>2.98</td>
<td>28</td>
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<td></td>
<td>5.31</td>
<td>15.18</td>
<td>187.09</td>
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<td>xxxx3</td>
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<td>3.59</td>
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<td>2.38</td>
<td>17.45</td>
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\(\text{⑪}}\) = \((\text{③}} \times \text{⑧} \times \text{⑩}) / (\text{⑦} \times \text{⑨})

\(\text{⑤}} = (1/24) \times 10^{a/(t+273)} - b\)

- \(a, b\): to be obtained by rearing experiments
- \(t\): water temperature \((\text{⑥}})\)

Survival rate of egg stage: constant value used as average by data sets of number of eggs for each three developmental stages collected for some years

\(\text{③}} = (n \times d) / (s \times r_1 \times r_2)\)

- \(n\): No. of eggs per haul
- \(d\): net depth
- \(s\): area of net mouth \((m^2)\)
- \(r_1\): calibration factor \((m/\text{rev})\)
- \(r_2\): No of revolution of flowmeter by net haul

\(\text{⑪}} = 30'\text{ Lat.} \times 30'\text{ Long. square} = (30 \times 1852)^2 \times \cos\text{ (Lat.)}\)
3-1. Estimation of abundance of spawning stocks by ichthyoplankton surveys (4)

Relative abundance

\[ N = \sum_{i} n \cdot S \]

- **N:** relative abundance (biomass or standing stock) of fish eggs or larvae
- **i:** sub-sea area
- **n:** (average) density of fish eggs or larvae in a square meter of sea surface (m²)
- **S:** area of sub-sea area (m²)
3-2. Forecasting year-class strength on the basis of the abundance of juveniles (1)

(Sassa et al., unpubl.)
3-2. Forecasting year-class strength on the basis of the abundance of juveniles (2)

Relationships between jack mackerel juvenile abundance and its 0-age recruitment by acoustic and mid-water trawl surveys or 0-age biomass by catch data of purse sein fisheries.

(Sassa et al., unpubl.)

Springtime juvenile abundance in the East China Sea would be important to determine age-0 recruitment into the Pacific and Japan Sea.