Biology of harmful red tide species – *Chattonella* spp. & other Raphidophytes

*WESTPAC* workshop on the development of research strategy for Harmful Algal Blooms
Institute of Oceanography, NHA TRANG, VIETNAM
19-22 Dec 2016

Toward the future development of HAB science in the Western Pacific
– What we know, and what we do not know on HABs

**Hong Chang Lim**
Faculty of Applied Sciences & Computing, Tunku Abdul Rahman University College

**Kazuya Takahashi, Mitsunori Iwataki**
Asian Natural Environmental Science Center, The University of Tokyo

**Chee Yew Sandric Leong**
Tropical Marine Science Institute, National University of Singapore

**Sing Tung Teng**
Faculty of Resource Science and Technology, Universiti Malaysia Sarawak

**Lik Sing Winnie Lau, Ing Kuo Law, Chui Pin Leaw, Po Teen Lim**
Bachok Marine Research Station, IOES, University of Malaya
Chattonella species list

- **Chattonella subsalsa** Biecheler 1936 – Type species of Chattonella
  - Type locality: Séte, Hérault, France

- **Chattonella marina** (Subrahmanyan) Hara & Chihara 1982 (basionym of **Hornellia marina** Subrahmanyan, 1954)
  - Malabar coasts, India

- **Chattonella minima** Hara & Chihara 1994
  - Kii Channel, Tokushima, Japan

- **Chattonella marina** var. **antiqua** (Hada) Demura & Kawachi 2009 (basionym of **Hemieutreptia antiqua** Hada, 1974)
  - Seto Inland Sea, Japan

- **Chattonella marina** var. **ovata** (Hara & Chihara) Demura & Kawachi 2009 (basionym of **Chattonella ovata** Hara & Chihara, 1994)
  - Ondo, Hiroshima Bay, Hiroshima, Japan
## Distribution of *Chattonella*

<table>
<thead>
<tr>
<th>Species</th>
<th>China</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>Singapore</th>
<th>Thailand</th>
<th>Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chattonella marina</em></td>
<td>+A</td>
<td>-</td>
<td>+B, C, G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Chattonella marina</em></td>
<td>+A</td>
<td>-</td>
<td>+A, C, D, G</td>
<td>+E</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>var. antiqua</td>
<td>-</td>
<td>-</td>
<td>+C, G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Chattonella marina</em></td>
<td>-</td>
<td>-</td>
<td>+C, G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>var. ovata</td>
<td>-</td>
<td>-</td>
<td>+C, G</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Chattonella minima</em></td>
<td>-</td>
<td>-</td>
<td>+F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Chattonella subsalsa</em></td>
<td>+A, G</td>
<td>-</td>
<td>+G</td>
<td>-</td>
<td>+E, G, I</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Chattonella sp.</em></td>
<td>-</td>
<td>+H</td>
<td>-</td>
<td>+E</td>
<td>-</td>
<td>-</td>
<td>+H</td>
<td>+J</td>
</tr>
</tbody>
</table>
Chattonella red tide outbreaks

Table 1 Red tide outbreaks of *Chattonella* spp. and related damages to fishery in Harima-Nada, eastern part of the Seto Inland Sea, from 1972 to 2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Red tide period</th>
<th>Maximum cell density (cell ml(^{-1}))</th>
<th>Damaged fish</th>
<th>Amount of loss (1,000 yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>Mid-July–mid-Aug.</td>
<td>1,500</td>
<td>Yellowtail</td>
<td>7,137,564</td>
</tr>
<tr>
<td>1977</td>
<td>Early Aug.–early Sep.</td>
<td>3,160</td>
<td>Yellowtail</td>
<td>2,970,000</td>
</tr>
<tr>
<td>1978</td>
<td>Early July–late Aug.</td>
<td>8,655</td>
<td>Yellowtail</td>
<td>3,277,269</td>
</tr>
<tr>
<td>1982</td>
<td>Late July–late Aug.</td>
<td>7,517</td>
<td>Yellowtail</td>
<td>768,288</td>
</tr>
<tr>
<td>1983</td>
<td>Early July–late Aug.</td>
<td>13,550</td>
<td>Yellowtail, Conger eel, Darkbanded rockfish, etc</td>
<td>54,032</td>
</tr>
<tr>
<td>1986</td>
<td>Mid-Aug.</td>
<td>385</td>
<td>Yellowtail</td>
<td>101,600</td>
</tr>
<tr>
<td>1987</td>
<td>Late July–early Sep.</td>
<td>1,030</td>
<td>Yellowtail, Black porgy, Gizzard shad, Flatfish, Darkbanded rockfish, Striped mullet</td>
<td>1,628,450</td>
</tr>
<tr>
<td>1999</td>
<td>Early July, late July, late Sep.</td>
<td>5,500</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2000</td>
<td>Late June–early July</td>
<td>95</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2003</td>
<td>Early July–late July</td>
<td>5,200</td>
<td>Yellowtail, Greater amberjack</td>
<td>1,155,177</td>
</tr>
<tr>
<td>2008</td>
<td>Late July</td>
<td>317</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Nishikawa et al. 2014
Hotspot:
- Seto Inland Sea, Japan
- Kagoshima Bay, Japan

Cell density warning level in Seto Inland Sea:
- 100 cells/mL of *Chattonella*
- *C. var. antiqua* easily reach warning level (consuming only small amount of N & P [0.78μm & 0.062μm]).

Imai & Yamaguchi, 2012
Morpho-characters

1. Presence/absence of mucocysts
2. Cell shape
3. Cell length
4. Cell width
5. Color of cells
6. Flagella
7. Shape and details of chloroplasts
8. Details of pyrenoid and thylakoids
Problems:
No rigid cell walls, lost of cellular shape and morphology through most of the fixatives. Difficult for identification and cells enumeration.

HEPES-buffered paraformaldehyde and glutaraldehyde (only for short-term fixation) (Katano et al. 2009)
Chattonella subsalsa
Type locality: Séte, Hérault, France

Chattonella marina complex

C. cf. subsalsa?
(Adriatic Sea)

C. subsalsa?
(GOM, USA; Iran; Singapore)

Lau et al. In Prep

Taxonomic Status
Malaysian *Chattonella* sp. strains:

- 4 CBCs with *C. marina*
- 6 CBCs with *C. subsalsa*

Lau et al. In Prep
Can information from ultrastructure help in species identification?
## Growth physiology

<table>
<thead>
<tr>
<th>Species</th>
<th>Maximal growth rate ($\mu_{\text{max}}$, divisions/day)</th>
<th>Maximal growth rate obtained (Temp °C, Salinity PSU)</th>
<th>Temperature tolerance (°C)</th>
<th>Salinity tolerance (PSU)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. marina</em></td>
<td>1.39</td>
<td>25, 20</td>
<td>15-30</td>
<td>10-35</td>
</tr>
<tr>
<td><em>C. marina var. antiqua</em></td>
<td>1.34</td>
<td>25, 25</td>
<td>15-30</td>
<td>10-35</td>
</tr>
<tr>
<td><em>C. marina var. ovata</em></td>
<td>1.49-2.09</td>
<td>25-30, 25-30</td>
<td>15-32.5</td>
<td>10-35</td>
</tr>
<tr>
<td><em>C. subsalsa</em></td>
<td>1.26</td>
<td>?</td>
<td>24-31</td>
<td>11-28</td>
</tr>
</tbody>
</table>

Growth properties:
- *C. var. antiqua* (N, 1.0 μm; P, 0.11 μm)
- *C. subsalsa* (N, 8.98 μm; P, 0.84 μm)
Chattonella cysts formation:
- Low light intensity
- Adhere to solid surface (79%)

Chattonella cysts germination:
- Darkness and low light condition

Life cycle

Summer, rise of water temperature

Winter, drop of water temperature

Imai & Katsuhiko, 1988; Yamaguchi & Imai, 1994
Vegetative cells of *Chattonella* observed from June-September; Red tides mainly in July-August in Seto Inland Sea.

Note: No study on ploidy of *C. subsalsa*. Cysts detected using qPCR at Delaware Bays, USA (Portune et al. 2009). Life cycle remained unknown.

Imai & Itoh, 1987
Other Raphidophytes

- **Heterosigma akashiwo** (Hada) Hada ex Hara & Chihara 1987
  - Setonaikai (Seto Inland Sea), Japan

- **Heterosigma minor** Tomas, Engesmo & Eikrem 2016
  - York River, Virginia, USA

Red tides forming species, fish-kill
Other raphidophytes

- **Fibrocapsa japonica** Toriumi & Takano 1973
  - Atsumi Bay, Mikawa Bay, Japan

Toxin:
- Decrease heart rates of fish
- Impaired oxygen flow to gills
- Fish mortality

(Khan et al. 1996; Bridgers et al. 2004; Fu et al. 2004)

© Gert Hansen

SCCAP K-0542
Fibrocapsa japonica
## Distribution

<table>
<thead>
<tr>
<th>Species</th>
<th>Heterosigma akashiwo</th>
<th></th>
<th>Fibrocapsa japonica</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Occurrence</td>
<td>Fish kill</td>
<td>Occurrence</td>
<td>Fish Kill</td>
</tr>
<tr>
<td>China</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Japan</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Malaysia</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Singapore</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Thailand</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Cysts and germination

1. SULG

4.

5.

6.
Emerging occurrence in the embayment in WESTPAC region;
Look for suitable fixatives for cell preservation (species identification);
More detailed morphological characterization to delimit species;
Understanding on life cycle of *Chattonella* and other raphidophytes in tropical region (bloom dynamics?).
Thank you.

http://harmfulalgae.info