Marine construction as a factor boosting *Aurelia aurita* s.l. blooms:
A case study of a new floating pier deployment in Hiroshima Bay, Japan

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Background

Increase of marine constructions is thought to be one of the causes of frequent jellyfish outbreaks in recent years, although no direct evidence has been reported.

The life cycle of *Aurelia aurita*

Increase of polyp habitat

Important to determine population size of the medusae
Similar scenario might occurred in the Inland Sea of Japan. During recent decades, both the bloom of *Aurelia aurita* medusae and increase of artificial coastline have co-occurred.

In April 2010, a new floating pier was installed in the Kuba fishing port, Hiroshima Bay.
The aim of this study

To test the bellow hypothesis with monitoring of **the medusae** before and after the pier installment and of **the polyp population**

Working hypothesis

‘Increase of marine constructions boosts blooms of *A. aurita* medusae’
Period: January 2010-July 2011

Frequency: weekly to monthly

Installment of a new pier: in the Kuba port on 19 April 2010

**Monitoring methods**

Medusa abundance and body diameter:
   oblique tows of a modified NORPAC net
   (315 µm mesh)

Polyps population dynamics:
   SCUBA or a specially designed **UPCAM**
Undersurface Polyp CAMera (UPCAM)

This enables quantitative monitoring of polyps on the undersurface of the pier without SCUBA.
Results 1: Environmental conditions

Ogata was reasonable as a control
Abundance and body diameter of medusae

Relative integrated medusa abundance in Ogata port during 29 Jan.-13 May:
Before (in 2010) : After (in 2011) = 1.00 : 0.32
Estimation of the numbers of exported medusae from Kuba port

The export rate of medusae was calculated with medusa abundance and water exchange rate. The water exchange rate \( Q_h \) was calculated from the equation (Takeoka 1989). Tidal data were from Japan Coast Guard 5th Regional Coast Guard Headquarters.

\[
Q_h = \frac{\beta \pi A \eta^2}{2 t_m h L W}
\]

- \( A \): area (m\(^2\))
- \( H \): water depth (m)
- \( L \): length (m)
- \( W \): width (m)
- \( \beta = 0.1 \)
- \( t_m \): \( M_2 \) cycle (seconds)
- \( \eta \): tidal range (m)
The numbers of exported medusae in Kuba port

Estimated medusa number in Kuba port excluding those from the new pier:

\[(0.7 \times 10^7 \times 0.32) = 0.2 \times 10^7 \text{ medusae}\]

\[\rightarrow 2.2 \times 10^7 \text{ medusae derived from the pier}\]
Estimated medusa number derived from the new pier in Kuba port

\[(2.5 \times 10^7 - 0.2 \times 10^7) = 2.2 \times 10^7 \text{ medusae pier}^{-1}\]

Large contribution of medusae from the new pier, increased the total number to **10.8-fold**

**Effect of the pier on number of exported medusae**

<table>
<thead>
<tr>
<th>Duration</th>
<th>Estimated medusa number (x 10^7 medusae)</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 Jan.-13 May, 2010</td>
<td>0.6</td>
</tr>
<tr>
<td>29 Jan.-13 May, 2011</td>
<td>2.0</td>
</tr>
<tr>
<td>Dec. 2009-May 2010</td>
<td>0.7</td>
</tr>
<tr>
<td>Dec. 2010-May 2011</td>
<td>2.5</td>
</tr>
</tbody>
</table>

(0.7 x 10^7 x 0.32 =) **0.2 x 10^7 medusae**

Estimated assuming same pattern of seasonal variation among the years
Population density of polyps and strobilae on the undersurface of the new pier

Density (ind. cm⁻²)

- Strobilae
- Polyp

Numbers of discs (discs strobila⁻¹)

A M J S O N D 2010

A M J S O N D 2011
Numbers of ephyrae liberated from the new floating pier

Total number of ephyrae produced ($TP$, ephyrae cm$^{-2}$) was estimated by the following equations:

$$P_i = N \times D \times C^{-1}$$

$$C = 108.53 \times e^{-0.221 \times T}$$

$$TP = \sum_{i=1}^{n} P_i$$

$P_i$: daily production rate of ephyrae (ephyrae cm$^{-2}$ day$^{-1}$)
$N$: density of strobilae (strobilae cm$^{-2}$)
$D$: numbers of discs per strobilae (discs strobila$^{-1}$)
$C$: duration of red-colored strobilae (days)
$T$: water temperature ($^\circ$C)

* The second equation (Duration of red-colored strobilae) was determined by the experiment.
Production rates of the ephyrae from the pier

2.3 \times 10^7 \text{ pier}^{-1}

Total numbers of ephyrae liberated from the pier:

2.3 \times 10^7 \text{ ephyrae pier}^{-1}

Number of exported medusae derived from the pier:

2.2 \times 10^7 \text{ medusae pier}^{-1}
<table>
<thead>
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<th>Number of exported medusae (x $10^7$ medusae)</th>
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<tbody>
<tr>
<td></td>
<td>From other than the pier</td>
</tr>
<tr>
<td><strong>Before</strong></td>
<td></td>
</tr>
<tr>
<td>Dec. 2009 to May 2010</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>After</strong></td>
<td></td>
</tr>
<tr>
<td>Dec. 2010 to May 2011</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The new floating pier boosted the production of ephyrae **10.8-fold**

The results clearly supported the hypothesis!
1. The maximum polyp density: 4.5 polyps cm$^{-2}$
Low category (due to low productivity in the second year)

2. The size of the pier: 6 x 48 m
Relatively small compared to others

Several countermeasures are needed!
Thank you