Invasive sea squirt Didemnum vexillum: testing multiple methods of control

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The invasive species - *Didemnum vexillum*

Invasive colonial sea-squirt native to Japan

European distribution: Ireland, U.K., France, Italy & The Netherlands

First documented in Ireland in 2005

Extensive fouling of ropes, chains, buoys, boat hulls and pontoons in Malahide marina

Significant negative impacts in natural ecosystems through overgrowth directly competing with native species for space

Fouls aquaculture equipment and commercially important species

Photos: *D.vex* covering mussels (Paul Barter), hull fouling (Damien Offer)
Why are we concerned about *D. vexillum*?

- Alters the diversity within marine ecosystems, smothering a wide range of marine organisms
- Directly competes with native biota for space - dominant competitor for space in fouling communities
- Reduces the complexity of habitats
- Disrupt the functioning of ecosystems
- Threat to our ecosystems and the services they provide
- Economic impacts to aquaculture

*D. vex* eelgrass photo (Dann Blackwood)
Why are we concerned about *D. vexillum*?

**Extensive fouling in aquaculture:**

- Economically damaging impacts
- Inhibits flow of water & food to stock
- Fouling of stock and equipment
- Increasing labour costs

Biofouling cost to European industry

- 230 million/year

30 tonnes of *D. vexillum* recorded on mussel farm in New Zealand

Jeopardising functioning of fertile fishing grounds in U.S.
Why should we take an active approach to the control of *Didemnum vexillum*?

Native and invasive fouling ascidian species are a major plague suffered by the shellfish industry. Invasive ascidians often cause the most significant damage of all fouling species. Newly introduced species (NIS) released from the constraints of natural enemies. The increasing rate of introduction in harbours (climate change is likely to facilitate the spread of ascidians) biofouling has cost the European industry between 5 and 10% of the industry value.

Photo credits: A. Gittenberger, J. Davidson, Fisheries & Ocean Canada, M.
Aspects of my research

Aim: To identify a **cost-effective** and **time efficient** treatment for the control of *Didemnum vexillum* in aquaculture that would both protect stock and reduce the potential further spread of the species.

Contribute to codes of practice for the control of invasive species in aquaculture.

Steps:
1. Reviewed literature to identify controls
2. Consulted with stakeholders (oyster and mussel farms)
3. Designed an experiment to test multiple options for control
4. Set up & ran my experiment on an oyster farm in Mayo
**Options for control?**

<table>
<thead>
<tr>
<th>Biological</th>
<th>Chemical</th>
<th>Mechanical</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Biological Options" /></td>
<td><img src="image2" alt="Chemical Options" /></td>
<td><img src="image3" alt="Mechanical Options" /></td>
</tr>
</tbody>
</table>

- **Biological**: Snail, crab, urchin, sea urchin, starfish, nudibranch.
- **Chemical**: Bleach, hydrated lime, sodium silicate, vinegar, H₂O₂.
- **Mechanical**: Tool, net, sack, brush, dry land.
Bag turning to control *D. vexillum*

Oyster farmers turn bags regularly to reduce the build up of fouling organisms.

Exposure during low tides.

As a soft bodied organism, *Didemnum* is vulnerable to desiccation.

Turning also prevents gregarious growth of oysters.

Bags are lighter and easier to manage with less fouling.

Enables natural flow of water through mesh bags.
Vinegar spray as a control for *D. vexillum*

Previously used to remove *D. vexillum* from:

- Aquaculture equipment
- Stock transfer
- Artificial and natural substrates

Success?

- Up to 80 - 100% removal in previous studies

Treatment details:

- 5% solution: acetic acid/sea water mix
- 30 seconds spraying bag evenly
- Dispensing ~ 600ml per bag
Combining treatments

Bag turning
Vinegar spray
Turn & Spray

? 50%

Treatment interaction

Impact severity

Treatment A
Treatment B
Additive
Antagonistic
Synergistic
Application of control treatments

Aim: To identify an eco-friendly cost-effective and time efficient treatment for the control of *Didemnum vexillum* in aquaculture

- How often do these treatments need to be applied?
- When should I apply to these treatments?
- Should I apply these treatments altogether or over a longer period of time?
**Factors**

- Turn
- Vinegar spray

**Experimental Design**

**Factors**

- Frequency
- Variance
- Timing

**Levels**

- H +
- L -
- C +
- S -
Controlling *D. vexillum* in aquaculture

Set up experiment on an oyster farm, West coast of Ireland

Ran for 6 months from March till September

Bag treatment corresponded with low tides every 2 weeks
Measuring the effects

<table>
<thead>
<tr>
<th><strong>D. vexillum</strong></th>
<th><strong>Biodiversity</strong></th>
<th><strong>Oyster</strong></th>
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</thead>
<tbody>
<tr>
<td>Percentage cover</td>
<td>Percentage cover of other fouling organisms (community structure)</td>
<td>Percentage mortality</td>
</tr>
<tr>
<td>Percentage of lobes</td>
<td>Total fouling biomass</td>
<td>Growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Condition</td>
</tr>
</tbody>
</table>
Percentage cover *Didemnum vexillum*
Percentage cover of lobed *Didemnum vexillum*
Percentage cover *Didemnum vexillum*
Total fouling biomass on oyster bags

- High Freq
- Low Freq

**Turn & Spray**

**Turn**

**Spray**

**Control**

Legend:
- Green: Spreader
- Blue: Cluster
- Yellow: Cluster
- Gray: Control
Oyster percentage mortality
<table>
<thead>
<tr>
<th>Turn &amp; Spray</th>
<th>Turn</th>
<th>Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Clustered Early</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Clustered Late</td>
<td></td>
<td></td>
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<tr>
<td>Reduced D. vex</td>
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<tr>
<td>Reduced % cover D. vex</td>
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<tr>
<td>Reduced fouling biomass</td>
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<tr>
<td>Water mortality</td>
<td></td>
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<tr>
<td>Most effective treatment</td>
<td></td>
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<tr>
<td>Most effective treatment</td>
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</tbody>
</table>

- **Star**: Effective
- **X**: Not effective
- **4th**: 4th position
- **1st**: 1st position
- **2nd**: 2nd position
- **3rd**: 3rd position
Acknowledgements

I would like to give a heartfelt thanks to everyone who helped me throughout my PhD

Dr Tasman Crowe
Dr Jan-Robert Baars
Grainne O’Brien, Mary Hannan, Catherine Morrison & Mo Mathies (B.I.M)
Sean O’Grady
Paddy & Margaret Grady
Ciara Murphy
Margaret & Danny
Anne, David, Mary, James, Helen & Claire
Bursary students & everyone who helped me over the summer
Luise, Megan, Suni, Christena, Lisa, Regina & Eric
Caroline, Paul, Chloe, Silvia & Camila
Dolaine, Dorothy, Rosie, Phil & Will
B.I.M for generously supporting my work
Impact of treatments on juvenile vs. adult oysters

**Factors**

- Age class
- Vinegar spray
- Frequency

**Response variables**

1) Oyster mortality
2) Oyster growth
3) Oyster condition

**Experimental Design**

- Levels:
  - Age class: < 1, > 1
  - Vinegar spray: +, -
  - Frequency: 1, 2, 4