Biofouling Management Guidelines for Mussel Culture



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Guide to common biofouling organisms

Tunicates/Ascidians:



Styela clava: 'clubbed tunicate'



Botrylloides & Botryllus sp.



Ciona intestinalis: 'sea vase'



Pyura dalbyi



Diplosoma listerianum

Guide to common biofouling organisms



Worms:



Pomatoceros taeniata: 'Coral/White worm'

Barnacles:



Amphibalanus variegatus Elminius modestus



Seastars:



Asterias amurensis: 'Northern Pacific seastar'



Coscinasterias muricata: '11-armed seastar'

Anemones:



Anthopleura aureoradiata



Guide to common biofouling organisms

Hydroids:



Ectopleura crocea: 'Pink mouthed hydroid'



Aglaophenia sp.



Obelia dichotoma: 'Winter hydroid'

Seaweeds:



Chaetomorpha linum. Image by: Julian Finn / Museum Victoria, Rights/Licence: CC BY (Attribution)

Chaetomorpha sp.



Gracilaria chilensis, pressing by J. Pocklington. Image by: Blair Patullo / Museum Victoria Rights/Licence: CC BY (Attribution)

Gracilaria chilensis



Undaria pinnatifida: 'Japanese kelp'

Monitor, manage or treat?



In order to decide wether monitoring, management or treatment is required, it is important to ask the following questions:

1) Characteristics of biofouling: What type of fouling is it?

2) Risk assessment:

What stage of production is affected? What are the risks of action *versus* no action?

| | Low priority | \rightarrow | High priority |
|------------------------------------|-----------------------------------------|-------------------------|---------------------------------|
| Number of lines affected | few | many | all |
| Density of biofouling | <10% | 10- 40% | >40% |
| Degree of fouling establishment | Starting to establish (juveniles) | Somewhat established | Well established (adults) |
| Potential impact | Lowest | Medium | Highest |
| Action | Monitor | Manage | Treat |



Monitor, manage or treat?

Monitor

Monitoring is as simple as **being aware** of the 'usual' flora and fauna of your culture area and keeping **written records** of <u>what</u> biofouling is prevalent, <u>when</u> it appears and <u>where</u> it becomes a nuisance. This information can be critical in allowing you to be prepared for future outbreaks.

If the biofouling is **new or unusual** or particularly heavy, **notify** <u>the relevant authority</u> immediately and collect a sample. It may be an introduced marine pest. Introduced species are opportunistic and can often be highly problematic as biofouling.



Manage

Ensure ropes are stocked at an **appropriate density** to avoid biofouling episodes. A density of **400 mussels per metre** will provide an optimum balance of good mussel retention and reduced fouling intensity.

Drop stock to depths of greater than 5 metres in anticipation of fouling periods; fouling can be up to 40% less at depths of 10 metres.

Plan **re-socking** for periods immediately <u>after settlement</u> of problem fouling species. The re-socking process will dislodge newly settled fouling.

Keep floats, vessels and other infrastructure <u>clean</u>; these act as hosts for biofouling, re-introducing problem organisms to culture areas and potentially **spreading pests** between them.



Treatment option 1 (T1):

| Seawater + 5% glacial acetic acid | | | |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Protect | Flammable: avoid sources of ignition (flame/spark) Acetic acid can irritate skin, eyes and the respiratory system. Wear Nitrile gloves and eye protection when handling, and avoid inhalation of vapours. Store in a well ventilated, bounded, secure storage area, away from direct sunlight. | | |
| Prepare | Dissolve acetic acid in seawater in a large tank to a concentration of 5% (50ml of glacial acetic acid per litre of seawater) in a well ventilated area. Ensure th solution is well mixed. | | |
| Procedure | Hoist fouled line from water Dip line in solution for <u>30 seconds</u> Remove line from solution. Return to water | | |

For acetic acid MSDS see: http://www.sciencelab.com/msds.php?msdsId=9922769

Monitor, manage or treat?



Treatment option 2 (T2):

Seawater + 6% hydrated lime (calcium hydroxide)

| Protect | Hydrated lime can irritate skin, eyes and the respiratory system. Wear gloves and eye protection when handling, and avoid inhalation of dust.Store in a cool protected place away from moisture, strong oxidants or acids and to minimize dust emissions. Storage in steel or concrete bins and silos, or plastic lined bags, is appropriate. | | |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Prepare | Dissolve hydrated lime in seawater in a large tank to a concentration of 6% (60g of hydrated lime (~99% calcium hydroxide) per litre of seawater) in a well ventilated area. Ensure the solution is well mixed. | | |
| Procedure | Hoist fouled line from water Air dry for 30 seconds Dip line in solution for <u>60 seconds</u> Remove line from solution Air dry for 30 seconds Return to water | | |

For calcium hydroxide MSDS see: http://www.sciencelab.com/msds.php?msdsId=9927122



Treatment option 3 (T3):

| 40°C seawater | | | |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Protect | Heated liquids and steam can burn. Wear gloves and eye protection when handling. | | |
| Prepare | Heat seawater to 40°C in a large tank | | |
| Procedure | Hoist fouled line from water Dip line in solution for <u>60 seconds</u> Remove line from solution. Return to water | | |



Treatment option 4 (T4):

40°C seawater + 2% acetic acid

| | Flammable: avoid sources of ignition (flame/spark) | | |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Protect | Acetic acid can irritate skin, eyes and the respiratory system. Wear Nitrile gloves and eye protection when handling, and avoid inhalation of vapours. | | |
| | Store in a well ventilated, bounded, secure storage area, away from direct sunlight. | | |
| Prepare | Dissolve acetic acid in seawater (heated to 40°C) in a large tank to a concentration of 2% (20ml of acetic acid per litre of seawater) in a well ventilated area. Ensure the solution is well mixed. | | |
| Procedure | Hoist fouled line from water Dip line in solution for <u>30 seconds</u> Remove line from solution. Return to water | | |

For acetic acid MSDS see: http://www.sciencelab.com/msds.php?msdsId=9922769



Treatment option 5 (T5):

| 40°C seawater + 5% citric acid | | | |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| Protect | Flammable: avoid sources of ignition (flame/spark) Citric acid can irritate skin, eyes and the respiratory system. Wear Nitrile gloves and eye protection when handling, and avoid inhalation of vapours. | | |
| | Store in a well ventilated, bounded, secure storage area, away from direct sunlight. | | |
| Prepare | Dissolve citric acid in seawater (heated to 40°C) in a large tank to a concentration of 5% (50g of 99.5% anhydrous citric acid per litre of seawater) in a well ventilated area. Ensure the solution is well mixed. | | |
| Procedure | Hoist fouled line from water Dip line in solution for <u>10 seconds</u> Remove line from solution. Return to water | | |

For citric acid MSDS see: http://www.sciencelab.com/msds.php?msdsId=9923494

'Quick pick' treatment decision guide



| Fouling species | T1 | T2 | Т3 | T4 | Т5 |
|------------------------------------------------------------------------------|---------------------------------|-----------------------------------|-------------------|-----------------------------------------|-----------------------------------------|
| | Seawater + 5% Acetic acid | Seawater + 6% hydrated lime | 40°C Seawater | 40°C seawater + 2% acetic acid | 40°C seawater + 2% citric acid |
| Styela clava & possibly other tough leathery tunicates | 50% mortality | 0% mortality | 10% mortality | 50% mortality | 100% mortality |
| Ciona intenstinalis & possibly other soft tunicates, anemones | 100% mortality | 50% mortality | 100% mortality | 100% mortality | 100% mortality |
| Ectopleura crocea & possibly other hydroids, seaweeds | 100% mortality | As yet untested | 100% mortality | 100% mortality | 100% mortality |
| Impacts on harvestable <i>Mytilus</i> galloprovincialis | 0-8% mortality* | 0-3% mortality | 0% mortality | 0% mortality | 0% mortality |

* Impacts more substantial for smaller mussels



FRDC Clubbed Tunicate: *Styela clava*





Clubbed Tunicate: Styela clava



Key features Brown, stalked, tough and leathery club-shaped Solitary individuals grow up to 16 cm long Often thickly covered with other marine fuzz-like fouling

Impacts

•Forms dense groups that compete with mussels for space and food leading to reduced mussel growth and condition

•Additional weight caused by extensive fouling can pull stock from lines

Increased operational costs

Decreased yields

Recommended treatment

•With access to heat: T5

•Without access to heat: T1 (if mussels >60mm or fouling severe)









Sea Vase: Ciona intestinalis



Key features
Smooth, fragile and gelatinous
Transparent with a yellow hue
Solitary individuals grow up to 20 cm long
Impacts

•Competes with mussels for space and food leading to reduced mussel growth and condition

•Additional weight caused by extensive fouling can pull stock from lines

- Increased operational costs
- •Decreased yields

Recommended treatment

- •With access to heat: T3
- Without access to heat: T1 or T2 (if mussels >60mm or fouling severe)



FRDC Pink Mouthed Hydroid: *Ectopleura crocea*







Pink Mouthed Hydroid: Ectopleura crocea



Key features

 Distinctive tufts of straight, tubular stems topped with large flower-like heads

•Often highly matted towards the base, trapping sediment

•Yellowish coloured stems up to 12 cm long, pink heads with long tentacles

Impacts

 Competes with mussels for space and food leading to reduced mussel growth and condition

•Preys on mussel spat

Increased operational costs

Decreased yields

Recommended treatment

•With access to heat: T3

•Without access to heat: T1 (if mussels >60mm or fouling severe)

FRDC Northern Pacific Seastar: Asterias amurensis



Juvenile



Key features

5 arms (although occasionally <5)
Yellow with distinctive purple markings
Only juveniles are likely to be found on mussel lines

Impacts

Active predator of mussels
Juveniles (<5 cm) only capable of consuming mussels <1 cm
Adults prefer mussels >2 - 3 cm
May reduce spat settlement and survival
Subsequent decrease in yields

Recommended treatment

 Pilot studies on juvenile seastars suggest: With access to heat: T4 Without access to heat: T1

Adult

Coral/White worm: Pomatoceros taeniata





Key features

Hard calcareous white ridged tube
Readily colonise hard surfaces including mussel shells
Older individuals may have purple stripes along ridges
Grows to 3 cm

Impacts

Grow on mussel shells reducing aesthetics, product sale value and thus profits
Heavily fouled mussels are often discarded
Difficult to remove calcified tube

Recommended treatment

•None of the treatments here are effective against white worm. FRDC project 2011/241 recommends dipping in seawater heated to 45-50°C for 45-50 seconds. However, in our study, 50°C treatments for 30 & 60 seconds resulted in high mussel mortality. We recommend caution when using these high temperatures against white worm.



Monitoring biofouling

Simple and ineffective

•Provides valuable information that may enable the avoidance of fouling and a pre-emptive treatment regime to be put in place

Alter husbandry practices

•Optimising stocking densities, rope types, line depth, cleaning schedules, etc will reduce the need for fouling treatment

Treatments

•Acquiring equipment to allow the use heated treatments is highly recommended, as this eliminates or reduces the need for chemicals, and treatments with heat suggested here result in no mussel mortality.

Contacts



The National Introduced Marine Pest Information System (NIMPIS): http://data.daff.gov.au/marinepests/

THE NATIONAL SYSTEM FOR THE PREVENTION AND MANAGEMENT OF MARINE PEST INCURSIONS

Australian Pesticides and Veterinary Medicines Authority (APVMP): http://apvma.gov.au/



Australian Government

Australian Pesticides and Veterinary Medicines Authority

For advice on the use of chemicals in aquaculture:

http://business.qld.gov.au/industry/fisheries/aquaculture/using-chemicals-in-aquaculture

Australian Mussel Industry Association: http://www.australianmussels.com.au/

