**Table S1.** An overview of common macrofouling organisms in marine shellfish culture, their documented adverse impacts, region of occurrence, shellfish species affected, and key references (updated from Fitridge et al. 2012).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fouling organism** | **Range of known impacts** | **Region** | **Shellfish species affected** | **Author(s)** |
| **Chordata: Ascidiacea**  *Ascidiella aspersa*  *Botrylloides violaceus*  *Botryllus* *schlosseri*  *Ciona intestinalis*  *Clavelina lepadiformis*  *Corella eumoyata*  *Dicarpa* sp.  *Didemnum perlucidum*  *Didemnum* sp.  *Didemnum vexillum*  *Diplosoma* sp.  *Diplsomosa listerianum*  *Herdmania momus*  *Pyura pachydermatina*  *Microcosmus exasperatus*  *Molgula citrina*  *Mogula manhattensis*  *Styela clava*  *Styela* *plicata*  *Trididemnum cereum* | Physical disruption to opening and closing of valves  Reduced size  Reduced growth Reduced flesh weight  Reduced condition  Mortality  Competition for food  Stock losses | Australia  Brazil  Canada  China  French Polynesia  Greece  India  Ireland  Japan  Netherlands  New Zealand  Norway  Persian Gulf  Spain  Sweden  USA | *Mytilus edulis*  *Perna canaliculus*  *Perna perna*  *Pinctada radiata* (=*fucata*)  *Pinctada maxima*  *Pinctada martensi* (=*fucata*)  *Pinctada fucata*  *Pinctada margaritifera*  *Mytilus galloprovincialis*  *Crassostra gigas*  *Kappaphycus alvarezii*  *Argopecten irradians irradians* | Takemura and Okutani (1955); Miyauti (1968); Alagarswami and Chellam (1976); Mohammad (1976); Dharmaraj et al. (1987); Chengxing (1990); Doroudi (1996); Carver et al. (2003); Coutts and Sinner (2004); Bourque et al. (2005); Mallet and Carver (2006); Forrest et al. (2007); Guenther and de Nys (2006); LeBlanc et al. (2007); Locke et al. (2007); Bonardelli (2008); Denny (2008); Ramsay et al. (2008); Daigle and Herbinger (2009); Gittenberger (2009); Rocha et al. (2009); Paetzold and Davidson (2010); Comeau et al. (2012); Kripa et al. (2012); Rolheiser et al. (2012); Woods et al. (2012); Antoniadou et al. (2013); Bullard et al. (2013); Fletcher et al. (2013); Sievers et al. (2013); Lacoste, Gueguen, et al. (2014); Lacoste, Le Moullac, et al. (2014); Sievers et al. (2014); Tettelbach et al. (2014); Holthuis et al. (2015); Marroig and Reis (2016); Atalah et al. (2016); Davidson et al. (2016); Watts et al. (2015); Casso et al. (2018); Palanisamy et al. (2018) |
| **Turbellaria:** **Polycladida**  *Imogine mcgrathi*  *Stylochus* sp.  *Stylochus matatsai*  *Stylochus frontalis* | Mortality | Australia  Mexico | *Crassostrea rhizophorae*  *Mytilus galloprovincialis*  *Pinctada margaritifera*  *Pinctada mazatlantica* | Littlewood and Marsbe (1990); Newman et al. (1993); Monteforte and Garcia-Gasca (1994); Pit and Southgate (2003) |
| **Annelida: Polychaeta**  *Boccardia knoxi*  *Hydroides dianthus*  *Hydroides elegans*  *Hydroides norvegicus*  *Platynereis australis*  *Polydora hoplura*  *Polydora websteri*  *Polydora ciliata*  *Polydora vulgaris*  *Pomatoceros caeruleus*  *Pomatoceros taeniata*  *Pomatoceros triqueter*  *Pseudopotamilla reniformis*  *Spirorbis* sp. | Blisters in nacreous layer  Weakened shell  Devaluation  Mortality | Arabian Gulf  Australia  Greece  India  Indian Ocean  Japan  New Zealand  Red Sea  UK  USA | *Haliotis* spp.  *Mytilus edulis*  *Pinctada fucata*  *Pinctada margaritifera*  *Mytilus galloprovincialis*  *Perna canaluculus* | Crossland (1957); Mohammad (1972); Blake and Evans (1973); Alagarswami and Chellam (1976); Mohammad (1976); Dharmaraj and Chellam (1983); Velayudhan (1983); Dharmaraj et al. (1987); Arakawa (1990); Wada (1991); Doroudi (1996); Taylor et al. (1997); Campbell and Kelly (2002); Lleonart et al. (2003); Kripa et al. (2012); Antoniadou et al. (2013); Sievers et al. (2014); Atalah et al. (2016); Watts et al. (2015) |
| **Algae**  *Ceramium* sp.  *Cladophora* sp.  *Codium fragile*  Cyanobacteria  *Gracilaria verrucosa*  *Undaria pinnatifida*  *Ulva rigida*  *Chaetomorpha* sp. *Cladophora vagabunda Ulva lactuca*  *Ulva flexuosa*  *Hypnea musciformis*  *Padina* sp.  *Porphyra* sp.  *Colpomenia* sp.  *Acanthophora spicifera*  *Spuridia* sp.  *Sargassum* sp.  *Amphiroa* sp.  *Jania* sp.  *Hincksia* sp.  *Hypnea spinella* | Shell erosion  Lost stock  Overgrowth  Smothering | Brazil  Canada  Greece  India  New Zealand | *Mytilus edulis*  *Perna canaliculus*  *Pinctada margaritifera*  *Pinctada fucata*  *Mytilus galloprovincialis*  *Kappaphycus alvarezii* | Mao Che et al. (1996); Garbary and Jess (2000); Naylor et al. (2001); Provan et al. (2005); Forrest and Blakemore (2006); Sharp et al. (2006); Wells et al. (2009); Kripa et al. (2012); Woods et al. (2012); Antoniadou et al. (2013); Sievers et al. (2014); Marroig and Reis (2016); Pochon et al. (2015); Atalah et al. (2016); Watts et al. (2015) |
| **Porifera**  *Callyspongia fibrosa*  *Cliona celata*  *Cliona dissimilis*  *Cliona margaritiferae*  *Cliona orientalis*  *Cliona* sp.  *Cliona vastifica*  *Dysidea* sp.  *Hymeniacidon* sp.  *Leucosolenia* sp.  *Pione velans* | Brittleness  Hinge instability  Blister formation  Shell damage  Shell deformity  Mortality | Australia  Brazil  French Polynesia  Greece  Indian Ocean  Persian Gulf  Red Sea | *Kappaphycus alvarezii*  *Chlamys islandica*  *Ostrea edulis*  *Pinctada fucata*  *Pinctada margaritifera*  *Pinctada margaritifera* var. *cumingii*  *Pinctada radiata*  *Placopecten magellanicus*  *Mytilus galloprovincialis* | Korringa (1952); Crossland (1957); Evans (1969); Mohammad (1972); Alagarswami and Chellam (1976);  Mohammad (1976); Thomas (1979); Dharmaraj and Chellam (1983); Velayudhan (1983); Dharmaraj et al. (1987); Pomponi and Merritt (1990); Barthel et al. (1994); Doroudi (1996); Mao Che et al. (1996); Wesche et al. (1997); Moase et al. (1999); Rosell et al. (1999); Fromont et al. (2005); Antoniadou et al. (2013); Lacoste, Le Moullac, et al. (2014); Marroig and Reis (2016) |
| **Mollusca: Bivalvia**  *Chama pacifica*  *Crassostrea* sp.  *Crassostrea* *rhizophorae*  *Hiatella arctica*  *Isognomon* sp.  *Limaria orientalis*  *Lithophaga* sp.  *Martesia* sp.  *Modiolarca impacta*  *Musculus impactus*  *Mytella charruana*  *Mytilus* sp.  *Mytilus galloprovincialis*  *Ostrea edulis*  *Ostrea equestris*  *Pinctada maculata*  *Pinctada* sp*.*  *Pinna* sp.  *Perna perna*  *Pteria* sp.  *Saccostrea* sp. | Physical disruption to opening and closing of valves  Damage to shell  Recession of shell growth  Shell deformity  Mortality  Competition for food and space  Reduced condition | Australia  Brazil  French Polynesia  Greece  India  Indonesia  New Zealand  Persian Gulf  Red Sea | *Crassostrea* *rhizophorae*  *Pinctada fucata*  *Pinctada margaritifera*  *Pinctada maxima*  *Pinctada radiata*  *Perna canaliculus*  *Mytilus galloprovincialis*  *Nodipecten nodosus*  *Kappaphycus alvarezii* | Takemura and Okutani (1955); Crossland (1957); Alagarswami and Chellam (1976); Dharmaraj and Chellam (1983); Doroudi (1996); Taylor et al. (1997); Guenther et al. (2006); Carraro et al. (2012); Woods et al. (2012); Antoniadou et al. (2013); Lacoste, Le Moullac, et al. (2014); Marroig and Reis (2016); Atalah et al. (2016); Watts et al. (2015); Lacoste et al. (2016); Forrest and Atalah (2017); South et al. (2017); das Chagas et al. (2018) |
| **Cnidaria: Hydrozoa**  *Amphisbetia bispinosa*  *Ectopleura crocea*  *Ectopleura* *larynx*  *Ectopleura* *warreni*  *Eutima japonica*  *Hydractinia angusta*  *Obelia* *bidentata*  *Obelia* sp.  *Pinnaria disticha*  *Tubularia crocea*  *Tubularia* sp. | Smothering  Recession of shell growth  Devaluation  Competition for food and space  Stress  Disruption to feeding  Physical disruption to opening and closing of valves  Facilitate settlement of other foulers  Deter shellfish recruitment | Australia  Brazil  Canada  Greece  Japan  New Zealand  USA | *Adamussium colbecki*  *Mizuhopecten yessoensis*  *Mytilus edulis*  *Mytilus gallopronvincialis*  *Perna canaliculus*  *Placopecten magellanicus*  *Kappaphycus alvarezii* | Claereboudt et al. (1994); Cerrano et al. (2001); Heasman and de Zwart (2004); Gretchis (2006); Guenther and de Nys (2006); Baba et al. (2007); Fitridge (2011); Antoniadou et al. (2013); Bullard et al. (2013); Fitridge and Keough (2013); Sievers et al. (2014); Marroig and Reis (2016); Atalah et al. (2016); Watts et al. (2015) |
| **Cnidaria: Anthozoa**  *Aiptassiogeton hyalnus*  *Corynactis australia*  *Aiptasia* sp. |  | French Polynesia  Greece  New Zealand | *Mytilus galloprovincialis*  *Pinctada margaritifera*  *Perna canaliculus* | Antoniadou et al. (2013); Lacoste, Gueguen, et al. (2014); Atalah et al. (2016) |
| **Arthropoda:** **Maxillopoda**  *Amphibalanus amphitrite*  *Balanus amphitrite communis*  *Balanus amphitrite variegates*  *Balanus trigonus*  *Balanus* sp.  *Megabalanus* sp*.*  *Perforatus perforatus*  *Tetraclita* sp. | Physical disruption to opening and closing of valves  Recession of shell growth  Mortality | Arabian Gulf  Australia  Brazil  Greece  India  Indonesia  Japan  New Zealand  Persian Gulf | *Kappaphycus alvarezii*  *Pinctada fucata*  *Pinctada martensi*  *Pinctada maxima*  *Pinctada radiata*  *Perna canaliculus*  *Mytilus galloprovincialis*  *Nodipecten nodosus* | Takemura and Okutani (1955); Miyauti (1968); Alagarswami and Chellam (1976); Mohammad (1976); Doroudi (1996); Taylor et al. (1997); de Nys and Ison (2004); Carraro et al. (2012); Kripa et al. (2012); Antoniadou et al. (2013); Marroig and Reis (2016); Atalah et al. (2016) |
| **Bryozoa**  *Bugula neritina*  *Bugula stolonifera*  *Crassimarginatella papulifera*  *Electra* sp*.*  *Leucosolenia* sp.  *Schizosmittina cinctipora* | Smothering  Competition for food and space  Disruption to feeding  Physical disruption to opening and closing of valves  Facilitate settlement of other foulers | Brazil  Greece  India  New Zealand | *Perna canaliculus*  *Pinctada fucata*  *Mytilus*  *galloprovincialis*  *Nodipecten nodosus* | Carraro et al. (2012); Kripa et al. (2012); Antoniadou et al. (2013); Marroig and Reis (2016); Atalah et al. (2016) |

**Table S2.** An overview of common macrofouling organisms in marine finfish culture, their documented adverse impacts, region of occurrence, fish species affected, and key references (updated from Fitridge et al. 2012).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fouling organism** | **Range of known impacts** | **Region** | **Fish species affected** | **Author(s)** |
| **Chordata: Ascidiacea**  *Ascidiella aspersa*  *Botrylloides* sp.  *Botryllus schlosseri*  *Botryllus* sp*.*  *Chelyosoma* sp.  Ciona intestinalis  *Cnemidocarpa bicornuta*  *Styela* sp.  *Styela* *plicata*  *Symplegma* sp.  *Trididemnum* sp. | Net occlusion  Increased drag  Cage deformation and structural fatigue  Increased disease risk  Harbouring of pathogens | Canada  Malaysia  Norway  UK  USA | *Epinephelus* sp.  *Gadus morhua*  *Lates calcarifer*  *Lutjanus* sp.  *Oncorhynchus tshawytscha*  *Salmo salar*  *Siganus* sp. | Milne (1975b); Braithwaite et al. (2007); Chambers et al. (2012); Atalah et al. (2013); Bloecher et al. (2013); Edwards et al. (2015); Swain and Shinjo (2014); Madin and Ching (2015); Hellebø et al. (2017) |
| **Mollusca: Bivalvia**  *Arca auriculata*  *Barbatia sinenis*  *Chlamys transquebaricus*  *Crassostrea* spp.  *Crassostrea madrasensis, Electroma georgiana*  *Hiatella arctica*  *Heteranomia squamula*  *Limnoperna fortune*  *Modiolus* sp.  *Mytilus edulis*  *Mytilus galloprovincialis*  *Pecten maximus*  *Perna canaliculus*  *Perna viridis*  *Pinctada* spp*.*  *Pinctada chemnitzi*  *Pinctada vulgaris*  *Pteria* sp*.*  *Saccostrea cucullate*  *Xenostrobus mangle* | Net occlusion  Increased drag  Cage deformation and structural fatigue  Harbouring of pathogens | Australia  Brazil  Canada  India  Malaysia  Norway  Singapore  UK  USA | *Epinephelus* sp.  *Lates calcarifer*  *Lutjanus* sp.  *Lutjanus argentimaculatus*  *Oncorhynchus tshawytscha*  *Rachycentron canadum*  *Salmo salar*  *Signaus* sp.  *Thunnus maccoyii*  *Trachinotus blochii* | Milne (1975a); Milne (1975b); Moring and Moring (1975); Lee et al. (1985); Cronin et al. (1999); Braithwaite et al. (2007); Greene and Grizzle (2007); Atalah et al. (2013); Bloecher et al. (2013); Edwards et al. (2015); Madin and Ching (2015); Hellebø et al. (2017); Gansel et al. (2017); Mhaddolkar et al. (2017); Godoy et al. (2018) |
| **Cnidaria: Anthozoa**  *Anthothoe albocincta*  *Bunodosoma sp.*  *Diadumene* sp.  *Diadumene neozelandica Mimetridium cryptum*  *Viatrix* sp. | Net occlusion  Likely cause for skin lesions | New Zealand  India | *Lates calcarifer*  *Lutjanus argentimaculatus*  *Oncorhynchus tshawytscha*  *Rachycentron canadum*  *Trachinotus blochii* | Atalah et al. (2013); Wybourne (2013); Atalah and Smith (2015); Mhaddolkar et al. (2017) |
| **Cnidaria: Hydrozoa**  *Bougainvilla* sp.  *Ectopleura crocea*  *Ectopleura exxonia*  *Ectopleura* *larynx*  *Eudendrium* sp.  *Eudendrium capillare*  *Garvei* sp.  *Obelia* sp.  *Obelia* *dichotoma*  *Obelia geniculata*  *Opercularella lacerate*  *Plumularia* sp.  *Tubularia* sp.  *Sarsia tubulosa* | Net occlusion  Increased drag  Reduced water flow  Harbouring of pathogens  Gill injuries | Canada  China  India  Ireland  Malaysia  New Zealand  Norway  USA | *Gadus morhua*  *Lates calcarifer*  *Lutjanus argentimaculatus*  *Oncorhynchus tshawytscha*  *Rachycentron canadum*  *Salmo salar Trachinotus blochii* | Hodson et al. (2000); Guenther et al. (2009); Madin et al. (2009); Guenther et al. (2010); Carl et al. (2011); Guenther et al. (2011); Baxter et al. (2012); Chambers et al. (2012); Atalah et al. (2013); Bloecher et al. (2013); Edwards et al. (2015); Gansel et al. (2015); Madin and Ching (2015); Hellebø et al. (2017); Mhaddolkar et al. (2017); Bi et al. (2018); Bloecher et al. (2018) |
| **Arthropoda: Crustacea**  *Balanus sp.*  *Balanus amphitrite*  *Balanus eburneus*  *Semibalanus cariosus*  *Caprella sp.*  *Caprella mutica*  *Caprella linearis*  *Aeginia longicornis*  *Jassa falcata* | Net occlusion | Canada  India  Malaysia  Norway | *Gadus morhua*  *Lates calcarifer*  *Lutjanus argentimaculatus*  *Rachycentron canadum*  *Salmo salar*  *Thunnus thynnus*  *Trachinotus blochii* | Chambers et al. (2012); Bloecher et al. (2013); Edwards et al. (2015); Swain and Shinjo (2014); Madin and Ching (2015); Mhaddolkar et al. (2017) |
| **Bryozoa**  *Bowerbankia* sp  *Bowerbankia imbricata*  *Bugula neritina*  *Cryptosula* sp.  *Electra Pilosa*  *Membranipora membranacea* | Net occlusion  Encrusting bryozoans provide attachment points for other organisms  Harbouring of pathogens | India  Norway  Malaysia  USA | *Lates calcarifer*  *Lutjanus argentimaculatus Rachycentron canadum*  *Salmo salar*  *Trachinotus blochii* | Bloecher et al. (2013); Swain and Shinjo (2014); Madin and Ching (2015); Hellebø et al. (2017); Mhaddolkar et al. (2017) |
| **Algae**  Filamentous algae  *Acrochaetium daviesii*  *Agloathamnion byssoides*  *Antithamnion* sp.  *Antithamnion cruciatum*  *Bangia fuchsopurpurea*  *Bryopsis* sp.  *Callithamniella tingitana*  *Callithamnion corymbosum*  *Ceramium* sp.  *Ceramium diaphanum*  *Ceramium flaccidum*  *Chondria tenuissima*  *Cladophora* sp.  *Cladophora dalmatica*  *Cyanophyceae*  *Derbesia tenuissima*  *Dasya ocellata*  *Desmarestia viridis*  *Diatomeae*  *Ectocarpus* sp.  *Ectocarpus siliculosus*  *Enteromorpha* spp.  *Enteromorpha clathrata*  *Erythrotrichia carnea*  *Falkenbergia rufolanosa*  *Feldmannia caespitula*  *Feldmania irregularis*  *Florideophyceae* sp.  *Fosliella farinosa*  *Gracilaria* sp.  *Laurencia obtusa*  *Lyngbya* sp.  *Myrionema orbiculare*  *Pneophyllum fragile*  *Polysiphonia* sp.  *Polysiphonia scopulorum*  *Polysiphonia stricta*  *Saccharina latissima*  *Spongomorpha* sp.  *Spyridia filamentosa*  *Titanoderma pustulatum*  *Ulothrix* spp.  *Ulva* spp.  *Ulva multiramosa*  *Ulva prolifera*  *Ulvophyceae* sp.  *Urospora peniciliformis*  *Wrangelia penicillata* | Net occlusion  Increased drag  Cage deformation and structural fatigue  Restriction of water exchange  Poor water quality  Limited oxygen availability  Reduced waste metabolite removal | Australia  Canada  Croatia  Malaysia  Norway  UK  USA | *Dicentrachus labrax*  *Epinephelus* sp.  *Lates calcarifer*  *Lutjanus* sp.  *Oncorhynchus tshawytscha*  *Salmo salar*  *Signaus* sp.  *Sparus aurata*  *Thunnus maccoyii* | Milne (1975a); Milne (1975b); Moring and Moring (1975); Hodson and Burke (1994); Cronin et al. (1999); Svane et al. (2006); Sliskovic et al. (2011); Bloecher et al. (2013); Edwards et al. (2015); Madin and Ching (2015); Gansel et al. (2017) |

**Table S3.** Statutory regulation and recommended best management practices associated with finfish aquaculture biofouling management.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Country** | | | **Summary** | **References** |
| ASC | | Salmon | **Recommended:** Copper treated nets must not be treated or high-pressure cleaned *in situ*. Low pressure cleaning of copper treated nets may be undertaken *in situ*. On land net cleaning sites must have suitable effluent treatment systems in place. Where copper treated nets are used, monitoring of copper levels outside the AZE must be undertaken and within acceptable limits. Any biocides used in net antifouling must be approved in legislation in the EU, USA or Australia. | ASC. (2017) |
| Seabass, Seabream and Meagre | **Recommended:** Any biocides used in net antifouling must be approved in legislation in the EU, USA, Australia or Japan. On land net cleaning sites must have suitable effluent treatment systems in place, including copper capture where copper is used. Biological waste must be stored and/or disposed of appropriately. | ASC. (2019) |
| Australia | | National | **Statutory:** None identified  **Recommended:** *In situ* cleaning to be undertaken in permitted areas within the marine farming lease only, in line with relevant regulations.  Routine *in situ* cleaning of mature/extensive biofouling in place of earlier/better maintenance practices is not recommended. Where the discharged materials meet relevant standards, *in situ* cleaning is acceptable however methods should be adopted to ensure minimal release of biological material into the water. Methods should catch biofouled material with a diameter greater than 50 micrometres to minimise the release of viable biofouling organisms back into the environment. Collected debris must be disposed of on land following relevant waste disposal requirements. *In situ* cleaning should not be done within or beside areas of high conservation value. Where suspected invasive or non-indigenous species are identified during cleaning, this should be reported to the relevant authority and cleaning stopped. | NSPMMPI. (2013)    Department of the Environment. and New Zealand Ministry for Primary Industries. (2015) |
| Tasmania | **Statutory:** Licences holders must adhere to any written requests regarding measures to mitigate against ecological effects from waste associated with fouling organisms.  **Recommended:** Vacuum only *in situ* methods to be used on nets treated with antifoulant. Non anti-fouled nets can be cleaned using the vacuum and blasting techniques together. Cleaning frequency should increase during periods of high fouling. Positioning should be considered to minimise impact on caged fish. | Within marine farming licences;  TSGA. (2013) |
| New South Wales | **Statutory:** Biofouling must be regularly removed. The impacts of biofouling management must be monitored following Water Quality and Benthic Environmental Monitoring Plans to mitigate potential impacts. In-site cleaning must be monitored for particulate impacts. Chemicals are not permitted in cleaning practices.  **Recommended:** none identified | NSW Department of Primary Industries. (2018) |
| Canada | | Nova Scotia and New Brunswick | **Statutory:** On-site cleaning of nets not recommended. *In situ* washing of lightly fouled nets is allowed for maintenance purposes. *In situ* washing must be done to maximize dispersal of waste materials away from nearby cages. Clean nets must be used at the beginning of each production cycle and replaced more often if necessary. No *in situ* net cleaning to be conducted at sites with sulphide concentrations over 3000μM.  Biofouling control activities are accepted however the operator must take reasonable measures to mitigate risk of serious harm to commercial, recreational and Aboriginal fisheries and deleterious substances (pest control products or biochemical oxygen demanding matter) must not be deposited in managing biofouling.  **Recommended:** None identified | Department of Environment and Local Government. (2012); Nova Scotia Fisheries and Aquaculture. (2018)  Canadian Government. (1985) (amended 2016); Fisheries and Oceans Canada. (2015) |
| British Columbia | **Statutory**: Activities which result in serious harm to commercial, recreational or Aboriginal fisheries, or to fish that support these fisheries must not be undertaken, unless given permission to do so from a relevant authority.  **Recommended:** None identified | Canadian Government. (1985) (amended 2016)) |
| Chile | | | **Statutory:** Copper coated nets (and others coated in non-degradable or bio-accumulative toxic anti-foulants) must be cleaned on land-based facilities. When undertaking *in situ* cleaning using vacuuming systems with retention, no more than 20 days must pass between cleans from October to March, and no more than 2 months must pass from April to September. The retained material must be disposed of on land, following regulatory requirements. If these time periods are exceeded cleaning must be carried out on land or in boats, pontoons and other naval artefacts, with prior authorization of the Maritime Authority.  When undertaking *in situ* cleaning with methods other than vacuum system with retention, no more than 15 days may pass between cleans from October to March, and no more than 2 months must pass from April To September.  Only non-degradable or bio-accumulative toxic anti-foulants accredited by the relevant body can be used.  **Recommended:** None identified | Ministerio de Economia (2001) (amended 2017)) |
| New Zealand | | | **Statutory:** None identified  **Recommended:** Routine *in situ* cleaning of mature/extensive biofouling in place of earlier/better maintenance practices is not recommended. Where the discharged materials meet relevant standards, *in situ* cleaning is acceptable however methods should be adopted to ensure minimal release of biological material into the water. Methods should catch biofouled material with a diameter greater than 50 micrometres to minimise the release of viable biofouling organisms back into the environment. Collected debris must be disposed of on land following relevant waste disposal requirements. *In situ* cleaning should not be done within or beside areas of high conservation value. Where suspected invasive or non-indigenous species are identified during cleaning, this should be reported to the relevant authority and cleaning stopped.  Regular cleaning and maintenance should be undertaken to minimise build-up of biofouling. Any new or innovative methods for reducing organics discharged during cleaning should be reported to AQNZ. Any new or notifiable pest species should be reported.  In low-flow environments (<9.5cm s-1) and where nets are coated in copper anti-foulants, *in situ* cleaning should not be used, nets should be removed and cleaned on land. Copper based anti-foulants may cause less environmental risk than *in situ* washing. Nets should be cleaned often enough to ensure that water flow and dissolved oxygen concentrations inside the nets are not too much reduced. Dissolved oxygen concentrations should be ≥70% saturations inside the net-pens. | Department of the Environment. and New Zealand Ministry for Primary Industries. (2015)  New Zealand Sustainable Aquaculture. (2015)  (Sim-Smith and Forsythe 2013) |
| Norway | | | **Statutory:** Only approved anti-foulants can be used.  Land-based net cleaning must not cause the release of hazardous chemicals at concentrations greater than the surrounding water, and any pollution caused must be negligible. The cleaning facilities discharge must not exceed 2kg Cu/yr. *In situ* cleaning is not regulated other than that the copper concentration in the sediment is monitored as to not exceed certain limits.  **Recommended:** None identified | European Parliament. (1998)  Norwegian Ministry of Climate and Environment (2004 (amended 2016))  (Standard Norge 2016) NS 9410:2016 |
| Scotland | | | **Statutory:** Only approved anti-foulants can be used (copper oxide and dichlofluanid antifoulants). Controlled Activities Regulations (CAR) licence holders must comply with approved anti-foulant manufacturer's instructions. CAR licences provide any requirements associated with biofouling control.  **Recommended:** Biofouling should not be allowed to build up so that water flow through cages is restricted. Where excessive biofouling is observed, this should be dealt with immediately. | European Parliament. (1998); SEPA. (2011)  CoGP Management Group. (2015) |
| USA | Florida | | **Statutory**: The discharge of waste from *in situ* net cleaning should be avoided. The use strategies to reduce biofouling and the need for *in situ* cleaning should be adopted (eg cleaner fish, fouling resistant materials, net changing, rotating cage designs or anti-foulant coatings). Any anti-foulant coatings used must be reported to the relevant body before use. *In situ* methods must include strategies to prevent solids accumulating on the sea floor, or a reduction in water quality. Biocidal net cleaning methods are not allowed.  **Recommended:** None identified | FDACS (2016) |

**Table S4.** An overview of common macrofouling organisms in marine seaweed culture, their documented adverse impacts, region of occurrence, seaweed species affected, and key references (updated from Fitridge et al. 2012). Note: The algae *Polysiphonia* (syn. *Neosiphonia*) *apiculate* and *Ulva prolifera* were given separate rows due to their specific impacts.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fouling organism** | **Range of known impacts** | **Region** | **Seaweed species affected** | **Author(s)** |
| **Chordata: Ascidiacea**  *Botrylloides* sp.  *Botryllus* sp.  *Ciona intestinalis*  *Didemnum* sp. | Degradation in blade quality Mortality Reduced bio-mitigation capacity Reduced biomass  Reduced growth | Brazil  Denmark  India  Norway  UK | *Kappaphycus alvarezii*  *Laminaria digitata*  *Saccharina latissimi* | Andersen et al. (2011); Marroig and Reis (2011); Veeragurunathan et al. (2015) Bruhn et al. (2016); Rolin et al. (2017) |
| **Annelida: Polychaeta**  Flukeworms  *Nereis* sp. |  | India | *Gracilaria dura* | Veeragurunathan et al. (2015) |
| **Algae**  *Acanthophora spicifera*  *Acanthophora* spp.  *Acrochaetium* sp.  *Acrosorium corallinarum*  *Antithamnionella* sp.  *Bryopsis* sp.  *Caulerpa racemosa*  *Centroceras* sp*.*  *Ceramium diaphanum*  *Ceramium nodulosum*  *Ceramium rubrum*  *Ceramium secundatum*  *Ceramium* sp.  *Chaetomorpha compressa*  *Chaetomorpha crassa*  *Chondracanthus tedii*  *Chondria californica*  *Chondrus crispus*  *Cladophera* sp.  *Cladophora pellucida*  *Cladophora vagabunda*  *Colpomenia sinuosa*  *Cystoseira myrica*  *Desmarestia* sp.  *Dictyota cervicornis*  *Dictyota dichotoma*  *Dictyota* sp.  *Ectocarpus acutus*  *Ectocarpus* spp.  *Enteromorpha intestinalis*  *Entomorpha* sp.  Filamentous algae  *Fosliella* sp.  *Giffordia* sp.  *Gracilaria edulis*  *Gracilariopsis tenuifrons*  *Griffordia johnsoni*  *Herposiphonia* sp.  *Hincksia granulosa*  *Hincksia mitchelliae*  *Hydroclathrus clathratus*  *Hydroclathrus* sp.  *Hypnea musciformis*  *Hypnea pannosa*  *Hypnea* sp.  *Hypnea spinella*  *Hypnea valentiae*  *Jania rubens*  *Laurencia majuscula*  *Laurencia snackeyi*  *Liagora ceranoides*  *Neosiphonia apiculata*  *Neosiphonia savatieri*  *Padina gymnospora*  *Platymonas suecica*  *Polysiphonia flaccidissima*  *Polysiphonia harveyi*  *Polysiphonia* spp.  *Rhizoclonium* sp.  *Sahlingia subintegra*  *Sargassum duplicatum*  *Sargassum palgiophyllum*  *Solieria tenera*  *Spyridia* spp*.*  *Streblonema* sp.  *Turbinaria conoides*  *Ulothrix flacca*  *Ulva clathrate*  *Ulva lactuca*  *Ulva reticulata*  *Ulva* spp. | Change in appearance  Competition for light, substrate and nutrition.  Decreased solar irradiance  Degradation in blade quality  Disease  Hydrodynamic effects  Increase in N content of biomass and P content  Loss of productivity by causing rafts to sink  Mortality  Reduced growth  Reduced photosynthesis  Reduced production  Tissue degradation | Brazil  Canada  Chile  China  Denmark  India  Ireland  Israel  Japan  Korea  Madagascar  Malaysia  New Zealand  Norway  Philippines  South Africa  Spain  Sweden  Taiwan  Thailand  UK  USA  Venezuela | *Alaria esculenta*  *Chondracanthus chamissoi*  *Chondrus crispus*  *Gracilaiopsis lemaneiformis*  *Gracilaria chilensis*  *Gracilaria conferta*  *Gracilaria dura*  *Gracilaria ferox*  *Gracilaria fisheri*  *Gracilaria foliifera*  *Gracilaria gracilis*  *Gracilaria multipartita*  *Gracilaria salicornia*  *Gracilaria* sp.  *Gracilaria tenuistipitata*  *Gracilaria tenuistipitata*  *Gracilaria tikvahiae*  *Kappaphycus alvarezii*  *Laminaria digitata*  *Laminaria hyperborea*  *Saccharina latissimia*  *Undaria pinnatifida* | Edelstein et al. (1976); Shang (1976); Chiang (1981); Guiry and Ottway (1981); Hansen et al. (1981); Yoneshigue-Braga and Baeta Neves (1981); Shacklock and Doyle (1983); Hansen (1984); Ren et al. (1984); Bidwell et al. (1985); Lipkin (1985); Pizarro and Barrales (1986); Brinkhuis et al. (1987); Edding et al. (1987); Friedlander et al. (1987); Buschmann and Kuschel (1988); Santelices and Doty (1989); Friedlander et al. (1991); Kuschel and Buschmann (1991); Anderson RJ et al. (1992); Bravo et al. (1992); Chiang (1992); Dawes (1992); Friedlander (1992); Haglund (1992); Oliveira (1992); Rincones et al. (1992); Ugarte and Santelices (1992); Buschmann and Gomez (1993); Haglund and Pedersen (1993); Pickering et al. (1993); Pizarro and Santelices (1993); Santelices and Varela (1993); Buschmann et al. (1994); Anderson BC et al. (1998); Capo et al. (1999); Leonardi et al. (2006); Vairappan (2006); Vairappan et al. (2008); Vairappan et al. (2009); Andersen et al. (2011); Marroig and Reis (2011); Peteiro and Freire (2013); Ateweberhan et al. (2015); Marinho et al. (2015); Veeragurunathan et al. (2015); Marroig and Reis (2016); Macchiavello et al. (2017); Rolin et al. (2017); Walls et al. (2017); Chirapart et al. (2018); Kerrison et al. (2018) |
| *Polysiphonia* (syn *Neosiphonia*) *apiculata* | Distortion of thallus  Precursor for secondary bacterial infection  Reduced growth  Scarcity or lack of availability of good quality propagules for re-planting purposes  Tissue degradation  Reduced carrageenan yield | Indonesia  Madagascar Malaysia Philippines  Tanzania | *Kappaphycus alvarezii* | Hurtado et al. (2006); Vairappan (2006); Vairappan et al. (2008); Hayashi et al. (2010); Borlongan et al. (2011); Vairappan et al. (2013); Ateweberhan et al. (2015); Borlongan et al. (2016); Tsiresy et al. (2016) |
| *Ulva prolifera* | Cause green tides | China | *Pyropia* (syn *Porphyra*) yezoensis | Liu et al. (2013); Fan et al. (2015); Keesing et al. (2016) |
| **Cyanobacteria**  *Lyngbya* *majuscule*  *Lyngbya* sp.  *Xenococcus* sp. | Tissue degradation | Chile  India | *Gracilaria chilensis*  *Gracilaria dura* | Shang (1976); Hansen et al. (1981); Lignell et al. (1987); Leonardi et al. (2006); Veeragurunathan et al. (2015) |
| **Porifera**  *Haplosclerida* sp. |  | Brazil | *Kappaphycus alvarezii* | Marroig and Reis (2011) |
| **Mollusca: Bivalvia**  *Anomia ephippium*  *Hiatella arctica*  *Modiolus* sp.  *Mytilus edulis*.  *Mytilus* sp.  *Perna perna* | Change in appearance  Degradation in blade quality  Hydrodynamic effects  Increase in N content of biomass and P content  Mortality  Reduced bio-mitigation capacity  Reduced biomass quality  Reduced growth | Brazil  Denmark  India  Ireland Norway UK | *Alaria esculenta*  *Gracilaria dura*  *Kappaphycus alvarezii*  *Laminaria digitata*  *Saccharina latissimi* | Cancino et al. (1987); Bartsch et al. (2008); Andersen et al. (2011); Marroig and Reis (2011); Forbord et al. (2012); Marinho et al. (2015); Veeragurunathan et al. (2015) Bruhn et al. (2016); Rolin et al. (2017); Walls et al. (2017) |
| **Cnidaria: Hydrozoa**  *Kirchenpaueria pinnata*  *Obelia geniculata* | Colour abnormalities in algal tissues  Decreased production  Degradation of taste and quality  Hydrodynamic effects  Reduced bio-mitigation capacity  Reduced biomass quality  Reduced growth | Chile  Denmark  Ireland  Korea  Spain | *Alaria esculenta*  *Gracilaria chilensis*  *Saccharina japonica*  *Saccharina latissimi*  *Undaria pinnatifida* | Park and Hwang (2012); Peteiro and Freire (2013); Bruhn et al. (2016); Walls et al. (2017) |
| **Cnidaria: Anthozoa**  *Boloceroides* sp. |  | India | *Gracilaria dura* | Veeragurunathan et al. (2015) |
| **Arthropoda: Maxillopoda**  *Balanus perforate*  *Balanus* sp. | Change in appearance  Increase in N content of biomass and P content | Denmark  India  Ireland | *Alaria esculenta*  *Gracilaria dura*  *Saccharina latissimi* | Marinho et al. (2015); Veeragurunathan et al. (2015); Walls et al. (2017) |
| **Bryozoa**  *Bowerbankia* sp.  *Bugula neritina*  *Bugula* spp.  *Crisia* sp.  *Echinochalina* sp.  *Electra pilosa*  *Electra pilosa*  *Membranipora mambranacea* | Change in appearance  Decreased flexibility of lamina  Degradation in blade quality  Hydrodynamic effects  Increase in N content of biomass and P content  Increased susceptibility to breakage  Mortality  Reduced commercial value of biomass | Brazil  Chile  India  Ireland  Norway  Denmark  UK | *Alaria esculenta*  *chamissoi*  *Chondracanthus*  *Gracilaria dura*  *Kappaphycus alvarezii*  *Laminaria digitata*  *Saccharina latissimi* | Bartsch et al. (2008); Andersen et al. (2011); Marroig and Reis (2011); Lüning and Mortensen (2015); Marinho et al. (2015); Veeragurunathan et al. (2015) Førde et al. (2016); Macchiavello et al. (2017); Rolin et al. (2017); Walls et al. (2017) |
| **Annelida: Polychaeta**  *Spirobranchus triqueter*  *Spirorbis carinatus* |  | Ireland | *Alaria esculenta* | Walls et al. (2017) |

**References**

Alagarswami K, Chellam A. 1976. On fouling and boring organisms and mortality of pearl oysters in the farm at Veppalodai, Gulf of Mannar. Indian J Fish. 23(1-2):10-22.

Andersen GS, Steen H, Christie H, Fredriksen S, Moy FE. 2011. Seasonal patterns of sporophyte growth, fertility, fouling, and mortality of *Saccharina latissima* in Skagerrak, Norway: implications for forest recovery. J Mar Biol. 2011:1-8.

Anderson BC, Smit AJ, Bolton JJ. 1998. Differential grazing effects by isopods on *Gracilaria gracilis* and epiphytic *Ceramium diaphanum* in suspended raft culture. Aquaculture. 169:99-109.

Anderson RJ, Levitt GJ, Dawes CP, Simons RH. 1992. Experimental growth of *Gracilaria* in Saldanha Bay, South Africa. In:Mshigeni KE, Bolton J, Critchley A et al., editors. Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Windhoek (Namibia): KE Mshigeni; p. 19-36.

Antoniadou C, Voultsiadou E, Rayann A, Chintiroglou C. 2013. Sessile biota fouling farmed mussels: diversity, spatio-temporal patterns, and implications for the basibiont. J Mar Biol Assoc UK. 93(06):1593-1607.

Arakawa KY. 1990. Competitord and fouling organisms in the hanging cultures of the Pacific oyster, *Crassostrea gigas* (Thunberg). Mar Behav Physiol. 17:67-94.

ASC. 2017. ASC Salmon Standard Version 1.1. Utrecht, The Netherlands: Salmon Aquaculture Dialogue.

ASC. 2019. ASC SeaBass, Seabream and Meagre Standard Version 1.0. Utrecht, The Netherlands: Aquaculture Stewardship Council.

Atalah J, Fletcher LM, Hopkins GA, Heasman K, Woods CMC, Forrest BM. 2016. Preliminary assessment of biofouling on offshore mussel farms. J World Aquacult Soc. 47(3):376-386.

Atalah J, Newcombe E, Hopkins G. 2013. Biofouling community composition at three salmon farms in Queen Charlotte Sound. Report No. 2396. Nelson (New Zealand): Cawthron Institute.

Atalah J, Smith KF. 2015. Assessment of stinging cells and identity of anemones at Ruakaka Bay salmon farm. Nelson (New Zealand): Cawthron Institute.

Ateweberhan M, Rougier A, Rakotomahazo C. 2015. Influence of environmental factors and farming technique on growth and health of farmed *Kappaphycus alvarezii* (cottonii) in south-west Madagascar. J Appl Phycol. 27(2):923-934.

Baba K, Miyazono A, Matsuyama K, Kohno S, Kubota S. 2007. Occurrence and detrimental effects of the bivalve-inhabiting hydroid *Eutima japonica* on juveniles of the Japanese scallop *Mizuhopecten yessoensis* in Funka Bay, Japan: relationship to juvenile massive mortality in 2003. Mar Biol. 151(5):1977-1987.

Barthel D, J. S, Barthel KG. 1994. The boring sponge *Cliona vastifica* in a subarctic population of *Chlamys islandica*. An example of balanced commensalism? In:van Soest RWM, van Kempen TMG, Braekman JC, editors. Sponges in time and space. Rotterdam (The Netherlands): AA Balkema; p. 289-296.

Bartsch I, Wiencke C, Bischof K, Buchholz CM, Buck BH, Eggert A, Feuerpfeil P, Hanelt D, Jacobsen S, Karez R et al. 2008. The genus *Laminaria sensu lato*: recent insights and developments. Eur J Phycol. 43(1):1-86.

Baxter E, Sturt M, Ruane N, Doyle T, McAllen R, Rodger H. 2012. Biofouling of the hydroid *Ectopleura larynx* on aquaculture nets in Ireland: Implications for finfish health. Fish Vet J. 13:18-30.

Bi C-W, Zhao Y-P, Dong G-H, Wu Z-M, Zhang Y, Xu T-J. 2018. Drag on and flow through the hydroid-fouled nets in currents. Ocean Eng. 161:195-204.

Bidwell RGS, McLachlan J, Lloyd NDH. 1985. Tank cultivation of Irish moss, *Chondrus crispus* Stackh. Bot Mar. 28(3):87-97.

Blake JA, Evans JW. 1973. *Polydora* and related genera as borers in mollusk shells and other calcareous substrates. Veliger. 15(235-249).

Bloecher N, Olsen Y, Guenther J. 2013. Variability of biofouling communities on fish cage nets: A 1-year field study at a Norwegian salmon farm. Aquaculture. 416–417:302-309.

Bloecher N, Powell M, Hytterod S, Gjessing M, Wiik-Nielsen J, Mohammad SN, Johansen J, Hansen H, Floerl O, Gjevre AG. 2018. Effects of cnidarian biofouling on salmon gill health and development of amoebic gill disease. PLoS ONE. 13(7):e0199842.

Bonardelli J. 2008. Antacid - your mussels' best friend. Fish Farming Int.(September):48-49.

Borlongan IAG, Luhan MRJ, Padilla PIP, Hurtado AQ. 2016. Photosynthetic responses of ‘*Neosiphonia* sp. epiphyte-infected’ and healthy *Kappaphycus alvarezii* (Rhodophyta) to irradiance, salinity and pH variations. J Appl Phycol. 28(5):2891-2902.

Borlongan IAG, Tibubos KR, Yunque DAT, Hurtado AQ, Critchley AT. 2011. Impact of AMPEP on the growth and occurrence of epiphytic *Neosiphonia* infestation on two varieties of commercially cultivated *Kappaphycus alvarezii* grown at different depths in the Philippines. J Appl Phycol. 23(3):615-621.

Bourque D, Le Blanc AR, Landry T, McNair N, Davidson J. 2005. Tunicate infested mussel aquaculture sites in Prince Edward Island, Canada. J Shellfish Res. 24:1261.

Braithwaite RA, Carrascosa MCC, McEvoy LA. 2007. Biofouling of salmon cage netting and the efficacy of a typical copper-based antifoulant. Aquaculture. 262:219-226.

Bravo A, Buschmann AH, Valenzuela ME, Uribe M, Vergara PA, Buitano MS. 1992. Evaluation of artificial intertidal enclosures for *Gracilaria* farming in southern Chile. Aquacult Eng. 11(3):203-216.

Brinkhuis BH, Levine HG, Schlenk CG, Tobin S. 1987. *Laminaria* cultivation in the Far East and North America. In:Bird KT, Benson PH, editors. Seaweed cultivation for renewable resources Developments in Aquaculture and Fisheries Science. Amsterdam (The Netherlands): Elsevier; p. 107-146.

Bruhn A, Tørring DB, Thomsen M, Canal-Vergés P, Nielsen MM, Rasmussen MB, Eybye KL, Larsen MM, Balsby TJS, Petersen JK. 2016. Impact of environmental conditions on biomass yield, quality, and bio-mitigation capacity of *Saccharina latissima*. Aquacult Env Interac. 8:619-636.

Bullard SG, Davis CV, Shumway SE. 2013. Seasonal patterns of ascidian settlement at an aquaculture facility in the Damariscotta River, Maine. J Shellfish Res. 32(2):255-264.

Buschmann AH, Gomez P. 1993. Interaction mechanisms between *Gracilaria chilensis* (Rhodophyta) and epiphytes. Hydrobiologia. 260/261:345-351.

Buschmann AH, Kuschel FA. 1988. Cultivo intermareal de *Gracilaria* sp: Colonización de esporas e interacción con *Ulva lactuca*. Biota. 4:107-113.

Buschmann AH, Mora OA, Gomez P, Bottger M, Buitano S, Retamales C, Vergara PA, Gutierrez A. 1994. *Gracilaria chilensis* outdoor tank cultivation in Chile: use of land-based salmon culture effluents. Aquacult Eng. 13(4):283-300.

Campbell DA, Kelly MS. 2002. Settlement of *Pomatoceros triqueter* (L.) in two Scottish Lochs, and factors determining its abundance on mussels grown in suspended culture. J Shellfish Res. 21(2):519-527.

Canadian Government. 1985. Fisheries Act 1985 (last amended 2016). Canada: Minister of Justice.

Cancino JM, Muñoz M, Orellana MC. 1987. Effects of epifauna on algal growth and quality of the agar produced by *Gracilaria verrucosa* (Hudson) Papenfuss. Hydrobiologia. 151(1):233-237.

Capo TR, Jaramillo JC, Boyd AE, Lapointe BE, Serafy JE. 1999. Sustained high yields of *Gracilaria* (Rhodophyta) grown in intensive large-scale culture. J Appl Phycol. 11(2):143-147.

Carl C, Guenther J, Sunde LM. 2011. Larval release and attachment modes of the hydroid *Ectopleura larynx* on aquaculture nets in Norway. Aquac Res. 42(7):1056-1060.

Carraro JL, Rupp GS, Mothes B, Lerner C, Wuerdig NL. 2012. Characterization of the fouling community of macroinvertebrates on the scallop *Nodipecten nodosus* (Mollusca, Pectinidae) farmed in Santa Catarina, Brazil. Cienc Mar. 38(3):577-588.

Carver CE, Chisholm A, Mallet AL. 2003. Strategies to mitigate the impact of *Ciona intestinalis* (L.) biofouling on shellfish production. J Shellfish Res. 22(3):621-631.

Casso M, Navarro M, Ordóñez V, Fernández-Tejedor M, Pascual M, Turon X. 2018. Seasonal patterns of settlement and growth of introduced and native ascidians in bivalve cultures in the Ebro Delta (NE Iberian Peninsula). Reg Stud Mar Sci. 23:12-22.

Cerrano C, Puce S, Chiantore M, Bavestrello G, Cattaneo-Vietti R. 2001. The influence of the epizoic hydroid *Hydractinia angusta* on the recruitment of the Antarctic scallop *Adamussium colbecki*. Polar Biol. 24(8):577-581.

Chambers M, Bunker J, Watson W, Howell W. 2012. Comparative growth and survival of juvenile Atlantic cod (*Gadus morhua*) cultured in copper and nylon net pens. J Aquacult Res Dev. 3:137.

Chengxing Z. 1990. Ecology of ascidians in Daya Bay. In:Huang Z, editor. Collected works on marine ecology in Daya Bay. Bejing (China): Ocean Publishing Press; p. 397-403.

Chiang YM. 1981. Cultivation of *Gracilaria* (Rhodophycophyta, Gigartinales) in Taiwan. In:Levring T, editor. Proceedings of the Tenth International Seaweed Symposium. Berlin (Germany): Walter de Gruyter; p. 569-574.

Chiang YM. 1992. Seaweed cultivation in Taiwan. In:Mshigeni KE, Bolton J, Critchley A et al., editors. Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Windhoek (Namibia): KE Mshigeni; p. 61-67.

Chirapart A, Praiboon J, Boonprab K, Puangsombat P. 2018. Epiphytism differences in the commercial species of *Gracilaria*, *G. fisheri*, *G. tenuistipitata*, and *G. salicornia*, from Thailand. J Appl Phycol. 30(6):3413-3423.

Claereboudt MR, Bureau D, Cote J, Himmelman JH. 1994. Fouling development and its effect on the growth of juvenile giant scallops (*Placopecten magellanicus*) in suspended culture. Aquaculture. 121:327-342.

CoGP Management Group. 2015. Code of Good Practice, Chapter 4: Seawater lochs.

Comeau LA, Sonier R, Hanson JM. 2012. Seasonal movements of Atlantic rock crab (*Cancer irroratus* Say) transplanted into a mussel aquaculture site. Aquac Res. 43:509-517.

Coutts ADM, Sinner J. 2004. An updated benefit-cost analysis of management options for *Didemnum vexillum* in Queen Charlotte Sound. Report prepared for Marlborough District Council. Cawthron Report No. 925. Nelson (New Zealand): Cawthron Institute.

Cronin ER, Cheshire AC, Clarke SM, Melville AJ. 1999. An investigation into the composition, biomass and oxygen budget of the fouling community on a tuna aquaculture farm. Biofouling. 13(4):279-299.

Crossland C. 1957. The cultivation of the mother-of-pearl oyster in the Red Sea. Aust J Freshwater Mar Res. 8:111-130.

Daigle RM, Herbinger CM. 2009. Ecological interactions between the vase tunicate (*Ciona intestinalis*) and the farmed blue mussel (*Mytilus edulis*) in Nova Scotia, Canada. Aquat Invasions. 4(1):177-187.

das Chagas RA, Barros MRF, dos Santos WCR, Herrmann M. 2018. Composition of the biofouling community associated with oyster culture in an Amazon estuary, Para State, North Brazil. Revista De Biologia Marina Y Oceanografia. 53(1):9-17.

Davidson JDP, Landry T, Johnson GR, Ramsay A, Quijón PA. 2016. A field trial to determine the optimal treatment regime for *Ciona intestinalis* on mussel socks. Manag Biol Invasion. 7(2):167-179.

Dawes CP. 1992. Rope cultivation of *Gracilaria* in Namibia: prospects. In:Mshigeni KE, Bolton J, Critchley A et al., editors. Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Windhoek (Namibia): KE Mshigeni; p. 99-109.

de Nys R, Ison O. 2004. Evaluation of antifouling products developed for the Australian pearl industry, FRDC Project No. 2000/254. Townsville (Australia): James Cook University.

Denny CM. 2008. Development of a method to reduce the spread of the ascidian *Didemnum vexillum* with aquaculture transfers. ICES J Mar Sci. 65:805-810.

Department of Environment and Local Government. 2012. The Environmental Managment Program for the Marine Finfish Cage Aquaculture Industry in New Brunswick.

Department of the Environment., New Zealand Ministry for Primary Industries. 2015. Anti-fouling and in-water cleaning guidelines. Canberra: Department of Agriculture.

Dharmaraj S, Chellam A. 1983. Settlement and growth of barnacle and associated fouling organisms on pearl culture farm in the Gulf of Mannar. Proc Symp on Coastal Aquaculture, Cochin, India, 1980. Part 2: Molluscan Culture. Cochin (India): Marine Biological Association of India.

Dharmaraj S, Chellam A, Velayudhan TS. 1987. Biofouling, boring and predation of pearl oyster. In:Alagarswami K, editor. Pearl Culture Central Marine Fisheries Research Institute Special Publication No 39. Cochin (India): CMFRI; p. 92-97.

Doroudi MS. 1996. Infestation of pearl oysters by boring and fouling organisms in the northern Persian Gulf. Indian J Mar Sci. 25(2):168-169.

Edding M, Macchiavello J, Black H. 1987. Culture of *Gracilaria* sp. in outdoor tanks: productivity. Hydrobiologia. 151:369-373.

Edelstein T, Bird CJ, Mclachlan J. 1976. Studies on *Gracilaria* 2. Growth under greenhouse conditions. Can J Bot. 54(19):2275-2290.

Edwards CD, Pawluk KA, Cross SF. 2015. The effectiveness of several commercial antifouling treatments at reducing biofouling on finfish aquaculture cages in British Columbia. Aquac Res. 46(9):2225-2235.

European Parliament. 1998. Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market. Official Journal of the European Communities.

Evans JW. 1969. Borers in the shell of the sea scallop, *Placopecten magellanicus*. Am Zool. 9(3):775-782.

Fan S, Fu M, Wang Z, Zhang X, Song W, Li Y, Liu G, Shi X, Wang X, Zhu M. 2015. Temporal variation of green macroalgal assemblage on *Porphyra* aquaculture rafts in the Subei Shoal, China. Estuar Coast Shelf Sci. 163:23-28.

FDACS. 2016. Aquaculture best management practices manual. Tallahassee (Florida): Florida Department of Agriculture and Consumer Services.

Fisheries and Oceans Canada. 2015. Aquaculture Activities Regulations. Canada: Minister of Justice.

Fitridge I. 2011. The ecology of hydroids (Hydrozoa: Cnidaria) in Port Phillip Bay, Australia, and their impacts as fouling species in longline mussel culture. Australia: The University of Melbourne.

Fitridge I, Dempster T, Guenther J, de Nys R. 2012. The impact and control of biofouling in marine aquaculture: a review. Biofouling. 28(7):649-669.

Fitridge I, Keough MJ. 2013. Ruinous resident: the hydroid *Ectopleura crocea* negatively affects suspended culture of the mussel *Mytilus galloprovincialis*. Biofouling. 29(2):119-131.

Fletcher LM, Forrest BM, Bell JJ. 2013. Impacts of the invasive ascidian *Didemnum vexillum* on green-lipped mussel *Perna canaliculus* aquaculture in New Zealand. Aquacult Env Interac. 4(1):17-30.

Forbord S, Skjermo J, Arff J, Handå A, Reitan KI, Bjerregaard R, Lüning K. 2012. Development of *Saccharina latissima* (Phaeophyceae) kelp hatcheries with year-round production of zoospores and juvenile sporophytes on culture ropes for kelp aquaculture. J Appl Phycol. 24(3):393-399.

Førde H, Forbord S, Handå A, Fossberg J, Arff J, Johnsen G, Reitan KI. 2016. Development of bryozoan fouling on cultivated kelp (*Saccharina latissima*) in Norway. J Appl Phycol. 28(2):1225-1234.

Forrest BM, Atalah J. 2017. Significant impact from blue mussel *Mytilus galloprovincialis* biofouling on aquaculture production of green-lipped mussels in New Zealand. Aquacult Env Interac. 9:115-126.

Forrest BM, Blakemore KA. 2006. Evaluation of treatments to reduce the spread of a marine plant pest with aquaculture transfers. Aquaculture. 257:333-345.

Forrest BM, Hopkins GA, Dodgshun TJ, Gardner JPA. 2007. Efficacy of acetic acid treatments in the management of marine biofouling. Aquaculture. 262:319-332.

Friedlander M. 1992. *Gracilaria conferta* and its epiphytes: the effect of culture conditions on growth. Bot Mar. 35(5):423-428.

Friedlander M, Krom MD, Ben-Amotz A. 1991. The effect of light and ammonium on growth, epiphytes and chemical constituents of *Gracilaria conferta* in outdoor cultures. Bot Mar. 34(3):161-166.

Friedlander M, Shalev R, Ganor T, Strimling S, Ben-Amotz A, Klar H, Wax Y. 1987. Seasonal fluctuations of growth rate and chemical composition of *Gracilaria* cf. *conferta* in outdoor culture in Israel. Hydrobiologia. 151:501-507.

Fromont J, Craig R, Rawlinson L, Alder J. 2005. Excavating sponges that are destructive to farmed pearl oysters in Western and Northern Australia. Aquac Res. 36:150-162.

Gansel LC, Endresen PC, Steinhovden KB, Dahle SW, Svendsen E, Forbord S, Jensen Ø. 2017. Drag on nets fouled with blue mussel (*Mytilus edulis*) and sugar kelp (*Saccharina latissima*) and parameterization of fouling. ASME Proceeedings of the 36th International Conference on Ocean, Offshore and Arctic Engineering. Volume 6: Ocean Space Utilization:V006T005A008.

Gansel LC, Plew DR, Endresen PC, Olsen AI, Misimi E, Guenther J, Jensen O. 2015. Drag of clean and fouled net panels - Measurements and parameterization of fouling. PLoS ONE. 10(7):e0131051.

Garbary DJ, Jess CB. 2000. Current status of the invasive alga *Codium fragile* in eastern Canada. J Phycol. 36:23.

Gittenberger A. 2009. Invasive tunicates on Zeeland and Prince Edward Island mussels, and management practices in The Netherlands. Aquat Invasions. 4(1):279-281.

Godoy AC, Corrêia AF, Rodrigues RB, Boscolo WR, Bittencourt F, Nervis JAL, Feiden A. 2018. Three native species as possible control for *Limnoperna fortunei* in net cage farming in the Itaipu Reservoir. Water Air Soil Pollut. 229:241.

Greene JK, Grizzle RE. 2007. Successional development of fouling communities on open ocean aquaculture fish cages in the western Gulf of Maine, USA. Aquaculture. 262:289-301.

Gretchis TS. 2006. What's putting some aquaculturists in a 'foul' mood? Fouling organisms are taking their toll in marine aquaculture. Wrack Lines. 5:8-10.

Guenther J, Carl C, Sunde LM. 2009. The effects of colour and copper on the settlement of the hydroid *Ectopleura larynx* on aquaculture nets in Norway. Aquaculture. 292:252-255.

Guenther J, de Nys R. 2006. Differential community development of fouling species on the pearl oysters *Pinctada fucata*, *Pteria penguin* and *Pteria chinensis* (Bivalvia, Pteriidae). Biofouling. 22(3):163-171.

Guenther J, de Nys R, Southgate PC. 2006. The effects of age and shell size of the Akoya pearl oyster *Pinctada fucata* (Bilvalvia, Pteriidae) on the accumulation of fouling organisms. Aquaculture. 253:366-373.

Guenther J, Fitridge I, Misimi E. 2011. Potential antifouling strategies for marine finfish aquaculture: the effects of physical and chemical treatments on the settlement and survival of the hydroid *Ectopleura larynx*. Biofouling. 27(9):1033-1042.

Guenther J, Misimi E, Sunde LM. 2010. The development of biofouling, particularly the hydroid *Ectopleura larynx*, on commercial salmon cage nets in Mid-Norway. Aquaculture. 300:120-127.

Guiry MD, Ottway B. 1981. Maricultural studies on *Gracilaria foliifera*, an agar producing seaweed. Proceedings of the Third Economic and Medicinal Plants Research Association Symposium. Cambridge (UK): University Botanic Gardens; p. 85-95.

Haglund K. 1992. Photosynthesis and growth of some marine algae, with emphasis on the rhodophyte *Gracilaria tenuistipitata*. Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science. Uppsala (Sweden): Uppsala University Publications; p. 48.

Haglund K, Pedersen M. 1993. Outdoor pond cultivation of the subtropical marine red alga *Gracilaria* *tenuistipitata* in brackish water in Sweden. Growth, nutrient uptake, co-cultivation with rainbow trout and epiphyte control. J Appl Phycol. 5(3):271-284.

Hansen JE. 1984. Strain selection and physiology in the development of *Gracilaria* mariculture. Hydrobiologia. 116:89-94.

Hansen JE, Packard JE, Doyle WT. 1981. Mariculture of red seaweeds. La Jolla (California): California Sea Grant College Program.

Hayashi L, Hurtado AQ, Msuya FE, Bleicher-Lhonneur G, Critchley AT. 2010. A review of *Kappaphycus* farming: prospects and constraints. In:Israel A, Einav R, Seckbach J, editors. Seaweeds and their Role in Globally Changing Environments. New York: Springer; p. 251-283.

Heasman K, de Zwart E. 2004. Preliminary investigation on *Amphisbetia bispinosa* colonisation on mussel farms in the Coromandel. Report prepared for the New Zealand Mussel Industry Council. Nelson (New Zealand): Cawthron Institute.

Hellebø A, Stene A, Aspehaug V. 2017. PCR survey for *Paramoeba perurans* in fauna, environmental samples and fish associated with marine farming sites for Atlantic salmon (*Salmo salar* L.). J Fish Dis. 40(5):661-670.

Hodson SL, Burke C. 1994. Microfouling of salmon‐cage netting: a preliminary investigation. Biofouling. 8(2):93-105.

Hodson SL, Burke CM, Bissett AP. 2000. Biofouling of fish-cage netting: the efficacy of a silicone coating and the effect of netting colour. Aquaculture. 184:277-290.

Holthuis TD, Bergström P, Lindegarth M, Lindegarth S. 2015. Monitoring recruitment patterns of mussels and fouling tunicates in mariculture. J Shellfish Res. 34(3):1007-1018.

Hurtado AQ, Critchley AT, Trespoey A, Lhonneur GB. 2006. Occurrence of *Polysiphonia* epiphytes in *Kappaphycus* farms at Calaguas Is., Camarines Norte, Phillippines. J Appl Phycol. 18(3-5):301-306.

Keesing JK, Liu D, Shi Y, Wang Y. 2016. Abiotic factors influencing biomass accumulation of green tide causing *Ulva* spp. on *Pyropia* culture rafts in the Yellow Sea, China. Mar Pollut Bull. 105(1):88-97.

Kerrison PD, Stanley MS, Hughes AD. 2018. Textile substrate seeding of *Saccharina latissima* sporophytes using a binder: An effective method for the aquaculture of kelp. Algal Res. 33:352-357.

Korringa P. 1952. Recent advances in oyster biology. Quart Rev Biol. 27:266-308.

Kripa V, Mohamed KS, Velayudhan TS. 2012. Seasonal fouling stress on the farmed pearl oyster, *Pinctada fucata*, from Southeastern Arabian Sea. J World Aquacult Soc. 43(4):514-525.

Kuschel FA, Buschmann AH. 1991. Abundance, effects and management of epiphytism in intertial cultures of *Gracilaria* (Rhodophyta) in southern Chile. Aquaculture. 92:7-19.

Lacoste E, Gueguen Y, Le Moullac G, Koua MS, Gaertner-Mazouni N. 2014. Influence of farmed pearl oysters and associated biofouling communities on nutrient regeneration in lagoons of French Polynesia. Aquacult Env Interac. 5(3):209-219.

Lacoste E, Le Moullac G, Levy P, Gueguen Y, Gaertner-Mazouni N. 2014. Biofouling development and its effect on growth and reproduction of the farmed pearl oyster *Pinctada margaritifera*. Aquaculture. 434:18-26.

Lacoste E, Raimbault P, Harmelin-Vivien M, Gaertner-Mazouni N. 2016. Trophic relationships between the farmed pearl oyster *Pinctada margaritifera* and its epibionts revealed by stable isotopes and feeding experiments. Aquacult Env Interac. 8:55-66.

LeBlanc N, Davidson J, Tremblay R, McNiven M, Landry T. 2007. The effect of anti-fouling treatments for the clubbed tunicate on the blue mussel, *Mytilus edulis*. Aquaculture. 264:205-213.

Lee H, Lim L, Cheong L. 1985. Observation on the use of antifouling paint in netcage fish farming in Singapore. Singapore J Prim Ind. 13:1-12.

Leonardi PI, Miravalles AB, Faugeron S, Flores V, Beltrán J, Correa JA. 2006. Diversity, phenomenology and epidemiology of epiphytism in farmed *Gracilaria chilensis* (Rhodophyta) in northern Chile. Eur J Phycol. 41(2):247-257.

Lignell A, Ekman P, Pedersen M. 1987. Cultivation technique for marine seaweeds allowing controlled and optimized conditions in the laboratory and on a pilotscale. Bot Mar. 30(5):417-424.

Lipkin Y. 1985. Outdoor cultivation of sea vegetables. Plant Soil. 89(1-3):159-183.

Littlewood DTJ, Marsbe LA. 1990. Predation on cultivated oysters, *Crassostrea rhizophorae* (Guilding), by the polyclad turbellarian flatworm, *Stylochus* (*Stylochus*) *frontalis* Verril. Aquaculture. 88(2):145-150.

Liu D, Keesing JK, He P, Wang Z, Shi Y, Wang Y. 2013. The world's largest macroalgal bloom in the Yellow Sea, China: formation and implications. Estuar Coast Shelf Sci. 129:2-10.

Lleonart M, Handlinger J, Powell M. 2003. Spionid mudworm infestation of farmed abalone (*Haliotis* spp.). Aquaculture. 221:85-96.

Locke A, Hanson JM, Ellis KM, Thompson J, Rochette R. 2007. Invasion of the southern Gulf of St. Lawrence by the clubbed tunicate (*Styela clava* Herdman): otential mechanisms for invasions of Prince Edward Island estuaries. J Exp Mar Biol Ecol. 342:69-77.

Lüning K, Mortensen L. 2015. European aquaculture of sugar kelp (*Saccharina latissima*) for food industries: iodine content and epiphytic animals as major problems. Bot Mar. 58(6).

Macchiavello J, Sepúlveda C, Basaure H, Sáez F, Yañez D, Marín C, Vega L. 2017. Suspended culture of *Chondracanthus chamissoi* (Rhodophyta: Gigartinales) in Caleta Hornos (northern Chile) via vegetative propagation with secondary attachment discs. J Appl Phycol. 30(2):1149-1155.

Madin J, Ching CV. 2015. Biofouling challenge and management methods in marine aquaculture. In:Mustafa S, Shapawi R, editors. Aquaculture Ecosystems: Adaptability and Sustainability West Sussex (United Kingdom): John Wiley & Sons, Ltd; p. 107-138.

Madin J, Chong VC, Basri B. 2009. Development and short-term dynamics of macrofouling assemblages on fish-cage nettings in a tropical estuary. Estuar Coast Shelf Sci. 83(1):19-29.

Mallet AL, Carver CE. 2006. Incorporating the New Zealand tunicate treatment technology into a tunicate management strategy for Indian point marine farms. Report prepared for the Aquaculture Association of Nova Scotia. Dartmouth (Nova Scotia): Mallet Research Services.

Mao Che L, Le Champion-Alsumard T, Boury-Esnault N, payri C, Golubic S, Bezac C. 1996. Biodegradation of shells of the black pearl oyster, *Pinctada margaritifera* var. cumingii, by microborers and sponges of French Polynesia. Mar Biol. 126:509-519.

Marinho GS, Holdt SL, Birkeland MJ, Angelidaki I. 2015. Commercial cultivation and bioremediation potential of sugar kelp, *Saccharina latissima*, in Danish waters. J Appl Phycol. 27(5):1963-1973.

Marroig RG, Reis RP. 2011. Does biofouling influence *Kappaphycus alvarezii* (Doty) Doty ex Silva farming production in Brazil? J Appl Phycol. 23(5):925-931.

Marroig RG, Reis RP. 2016. Biofouling in Brazilian commercial cultivation of *Kappaphycus alvarezii* (Doty) Doty ex P. C. Silva. J Appl Phycol. 28(3):1803-1813.

Mhaddolkar SS, Loka J, Philipose KK, Dineshbabu AP. 2017. Experimental studies on macro fouling communities on net panels at marine cage farm of Kawar, India. Int J Fish Aquat Stud. 5(2):184-187.

Milne P. 1975a. Fouling of marine cages - part one. Fish Farming Int. 2(3):15-19.

Milne P. 1975b. Fouling of marine cages - part two: further trials in Scottish lochs. Fish Farming Int. 2(3):18-21.

Ministerio de Economia. 2001. Reglamento Ambiental Para La Acuicultura. Santiago.

Miyauti T. 1968. Studies on the effect of shell cleaning on pearl culture - III. The influence of fouling organisms upon the oxygen consumption in the Japanese pearl oysters. Jpn J Ecol. 18(1):40-43.

Moase PB, Wilmont A, Parkinson SA. 1999. *Cliona* - an enemy of the pearl oyster *Pinctada maxima* in the West Australian pearling industry. SPC Pearl Oyster Inform Bull. 13:27-28.

Mohammad MBM. 1972. Infestation of the pearl oyster *Pinctada margaritifera* (Linne) by a new species of *Polydora* in Kuwait, Arabian Gulf. Hydrobiologia. 39:463-477.

Mohammad MBM. 1976. Relationship between biofouling and growth of pearl oyster *Pinctada fucata* Gould in Kuwait, Arabian Gulf. Hydrobiologia. 51(2):129-138.

Monteforte M, Garcia-Gasca A. 1994. Spat collection studies on pearl oysters *Pinctada mazatlantica* and *Pteria sterna* (Bivalvia, Pteriidae) in Bahia de la Paz, South Baja California, Mexico. Hydrobiologia. 291:21-34.

Moring JR, Moring KA. 1975. Succession of net biofouling material and its role in the diet of pen-cultured chinook salmon. Progressive Fish-Culturist. 37(1):27-30.

Naylor RL, Williams SL, Strong DR. 2001. Aquaculture - a gateway for exotic species. Science. 294:1655-1656.

New Zealand Sustainable Aquaculture. 2015. Sustainable Managment Framework: New Zealand Salmon. Aquaculture New Zealand.

Newman LJ, Cannon LRG, Govan H. 1993. *Stylochus* (*Imogene*) *matatasi* n. sp. (Platyhelminthes, Polycladida): pest of cultured giant clams and pearl oysters from Solomon Islands. Hydrobiologia. 257(3):185-189.

Norwegian Ministry of Climate and Environment. 2004 (amended 2016). Pollution Control Act [in Norwegian: Forskrift om begrensning av forurensning (forurensningsforskriften); Del 7. Krav til forebygging av forurensning fra visse virksomheter eller utslippskilder; Kapittel 25. Forurensning fra vask og impregnering av oppdrettsnøter]. In:Government of Norway, editor. lovdata.no.

Nova Scotia Fisheries and Aquaculture. 2018. Environmental Monitoring Program Framework for Marine Aquaculture in Nova Scotia.

NSPMMPI. 2013. National biofouling management guidelines for the aquaculture industry. Canberra (Australia): Commonwealth of Australia.

NSW Department of Primary Industries. 2018. NSW Marine Waters Sustainable Aquaculture Strategy. NSW Department of Primary Industries.

Oliveira EC. 1992. Seaweed exploitation and cultivation in Brazil. In:Mshigeni KE, Bolton J, Critchley A et al., editors. Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Windhoek (Namibia): KE Mshigeni; p. 283-294.

Paetzold SC, Davidson J. 2010. Viability of golden star tunicate fragments after high-pressure water treatment. Aquaculture. 303(1-4):105-107.

Palanisamy SK, Thomas OP, McCormack GP. 2018. Bio-invasive ascidians in Ireland: A threat for the shellfish industry but also a source of high added value products. Bioengineered. 9(1):55-60.

Park CS, Hwang EK. 2012. Seasonality of epiphytic development of the hydroid *Obelia geniculata* on cultivated *Saccharina japonica* (Laminariaceae, Phaeophyta) in Korea. J Appl Phycol. 24(3):433-439.

Peteiro C, Freire O. 2013. Epiphytism on blades of the edible kelps *Undaria pinnatifida* and *Saccharina latissima* farmed under different abiotic conditions. J World Aquacult Soc. 44(5):706-715.

Pickering TD, Gordon ME, Tong LJ. 1993. Effect of nutrient pulse concentration and frequency on growth of *Gracilaria chilensis* plants and levels of epiphytic algae. J Appl Phycol. 5(5):525-533.

Pit JH, Southgate PC. 2003. Fouling and predation; how do they affect growth and survival of the blacklip pearl oyster, *Pinctada margaritifera*, during nursery culture? Aquacult Int. 11(6):545-555.

Pizarro A, Barrales H. 1986. Field assessment of two methods for planting the agar-containing seaweed, *Gracilaria*, in Northern Chile. Aquaculture. 59:31-43.

Pizarro A, Santelices B. 1993. Environmental variation and large-scale *Gracilaria* production. Hydrobiologia. 261:357-363.

Pochon X, Atalah J, Wood SA, Hopkins GA, Watts A, Boedeker C. 2015. *Cladophora ruchingeri* (C. Agardh) Kützing, 1845 (Cladophorales, Chlorophyta): a new biofouling pest of green-lipped mussel *Perna canaliculus* (Gmelin, 1791) farms in New Zealand. Aquat Invasions. 10(2):123-133.

Pomponi SA, Merritt DW. 1990. Distribution and life history of the boring sponge *Cliona truitti* in the upper Chesapeake Bay. In:Rutzler K, editor. New perspectives in sponge biology Third Int Conf on the Biology of Sponges, 1985. Washington (DC): Smithsonian Institution Press; p. 384-413.

Provan J, Murphy S, Maggs CA. 2005. Tracking the invasive history of the green alga *Codium fragile* ssp. *tomentosoides*. Mol Ecol. 14:189-194.

Ramsay A, Davidson J, Landry T, Strylin H. 2008. The effect of mussel seed density on tunicate settlement and growth for the cultured mussel, *Mytilus edulis*. Aquaculture. 275:194-200.

Ren GZ, Wang JC, Chen MQ. 1984. Cultivation of *Gracilaria* by means of low rafts. Hydrobiologia. 116:72-76.

Rincones RE, Rubio JN, Racca EC. 1992. *Gracilaria* pilot farming in Venezuela. In:Mshigeni KE, Bolton J, Critchley A et al., editors. Proceedings of the First International Workshop on Sustainable Seaweed Resource Development in Sub-Saharan Africa. Windhoek (Namibia): KE Mshigeni; p. 309-318.

Rocha RM, Kremer LP, Baptista MS, Metri R. 2009. Bivalve cultures provide habitat for exotic tunicates in southern Brazil. Aquat Invas. 4:195-205.

Rolheiser KC, Dunham A, Switzer SE, Pearce CM, Therriault TW. 2012. Assessment of chemical treatments for controlling *Didemnum vexillum*, other biofouling, and predatory sea stars in Pacific oyster aquaculture. Aquaculture. 364:53-60.

Rolin C, Inkster R, Laing J, McEvoy L. 2017. Regrowth and biofouling in two species of cultivated kelp in the Shetland Islands, UK. J Appl Phycol. 29(5):2351-2361.

Rosell D, Uriz MJ, Martin D. 1999. Infestation by excavating sponges on the oyster (*Ostrea edulis*) populations of the Blanes littoral zone (north-western Mediterranean Sea). J Mar Biol Assoc UK. 79:409-4013.

Santelices B, Doty MS. 1989. A review of *Gracilaria* farming. Aquaculture. 78:95-133.

Santelices B, Varela D. 1993. Exudates from *Gracilaria chilensis* stimulate settlement of epiphytic ulvoids. Hydrobiologia. 261:327-333.

SEPA. 2011. Permitted Substances Working Plan. Scottish Environment Protection Agency

Shacklock PF, Doyle RW. 1983. Control of epiphytes in seaweed cultures using grazers. Aquaculture. 31:141-151.

Shang YC. 1976. Economic aspects of *Gracilaria* culture in Taiwan. Aquaculture. 8(1):1-7.

Sharp GJ, Macnair N, Campbell E, Butters A, Ramsay A, Semple R. 2006. Fouling of mussel (*Mytilus edulis*) collectors by algal mats: dynamics, impacts and symptomatic treatment in P.E.I. Canada. ScienceAsia. 32:87-97.

Sievers M, Dempster T, Fitridge I, Keough MJ. 2014. Monitoring biofouling communities could reduce impacts to mussel aquaculture by allowing synchronisation of husbandry techniques with peaks in settlement. Biofouling. 30(2):203-212.

Sievers M, Fitridge I, Dempster T, Keough MJ. 2013. Biofouling leads to reduced shell growth and flesh weight in the cultured mussel *Mytilus galloprovincialis*. Biofouling. 29(1):97-107.

Sim-Smith C, Forsythe A. 2013. Comparison of the international regulations and best management practices for marine finfish farming. Ministry for Primary Industries, New Zealand Government.

Sliskovic M, Jelic-Mrcelic G, Antolic B, Anicic I. 2011. The fouling of fish farm cage nets as bioindicator of aquaculture pollution in the Adriatic Sea (Croatia). Environ Monit Assess. 173(1-4):519-532.

South PM, Floerl O, Jeffs AG. 2017. Differential effects of adult mussels on the retention and fine-scale distribution of juvenile seed mussels and biofouling organisms in long-line aquaculture. Aquacult Env Interac. 9:239-256.

Svane I, Cheshire A, Barnett J. 2006. Test of an antifouling treatment on tuna fish-cages in Boston Bay, Port Lincoln, South Australia. Biofouling. 22(4):209-219.

Swain G, Shinjo N. 2014. Comparing biofouling control treatments for use on aquaculture nets. Int J Mol Sci. 15(12):22142-22154.

Takemura Y, Okutani R. 1955. Notes on animals attached to the shells of the silver-lip pearl oyster, *Pinctada maxima* (Jameson), collected from the "East" fishing ground of the Arafura Sea. Bull Jpn Soc Sci Fish. 21(2):92-101.

Taylor JJ, Southgate PC, Rose RA. 1997. Fouling animals and their effect on the growth of silver-lip pearl oysters, *Pinctada maxima* (Jameson) in suspended culture. Aquaculture. 153:31-40.

Tettelbach ST, Tetrault K, Carroll J. 2014. Efficacy of Netminder®silicone release coating for biofouling reduction in bay scallop grow-out and comparative effects on scallop survival, growth and reproduction. Aquac Res. 45(2):234-242.

Thomas PA. 1979. Boring sponges destructive to economically important molluscan beds and coral reefs in Indian seas. Indian J Fish. 26:163-200.

TSGA. 2013. Environmental Best Management Practice Guideline for In situ Net Cleaning of Salmon Cages using Marine Inspector Cleaner (MIC). Tasmania (Australia): Tasmanian Salmonid Growers Association.

Tsiresy G, Preux J, Lavitra T, Dubois P, Lepoint G, Eeckhaut I. 2016. Phenology of farmed seaweed *Kappaphycus alvarezii* infestation by the parasitic epiphyte *Polysiphonia* sp. in Madagascar. J Appl Phycol. 28(5):2903-2914.

Ugarte R, Santelices B. 1992. Experimental tank cultivation of *Gracilaria chilensis* in central Chile. Aquaculture. 101:7-16.

Vairappan CS. 2006. Seasonal occurrences of epiphytic algae on the commercially cultivated red alga *Kappaphycus alvarezii* (Solieriaceae, Gigartinales, Rhodophyta). J Appl Phycol. 18(3-5):611-617.

Vairappan CS, Anangdan SP, Tan KL, Matsunaga S. 2009. Role of secondary metabolites as defense chemicals against ice-ice disease bacteria in biofouler at carrageenophyte farms. J Appl Phycol. 22(3):305-311.

Vairappan CS, Chung CS, Hurtado AQ, Soya FE, Lhonneur GB, Critchley A. 2008. Distribution and symptoms of epiphyte infection in major carrageenophyte-producing farms. J Appl Phycol. 20(5):477-483.

Vairappan CS, Chung CS, Matsunaga S. 2013. Effect of epiphyte infection on physical and chemical properties of carrageenan produced by *Kappaphycus alvarezii* Doty (Soliericeae, Gigartinales, Rhodophyta). J Appl Phycol. 26(2):923-931.

Veeragurunathan V, Eswaran K, Malarvizhi J, Gobalakrishnan M. 2015. Cultivation of *Gracilaria dura* in the open sea along the southeast coast of India. J Appl Phycol. 27(6):2353-2365.

Velayudhan TS. 1983. On the occurrence of shell boring polychaetes and sponges on the pearl oyster *Pinctada fucata* and control of boring organisms. Proc Symp on Coastal Aquaculture, Cochin, India, 1980. Part 2: Molluscan Culture. Cochin (India): Marine Biological Association of India.

Wada KT. 1991. The pearl oyster, *Pinctada fucata* (Gould) (Family Pteriidae). In:Menzel W, editor. Estuarine and marine bivalve mollusk culture. Boca Raton (Florida): CRC Press; p. 245-260.

Walls AM, Edwards MD, Firth LB, Johnson MP. 2017. Successional changes of epibiont fouling communities of the cultivated kelp *Alaria esculenta*: predictability and influences. Aquacult Env Interac. 9:57-71.

Watts AM, Hopkins GA, Goldstien SJ. 2015. Characterising biofouling communities on mussel farms along an environmental gradient: a step towards improved risk management. Aquacult Env Interac. 8:15-30.

Wells FE, McDonald JI, Huisman J. 2009. Introduced marine species in Western Australia. Fisheries occasional publication No. 57. Perth (Australia): Department of Fisheries.

Wesche SJ, Adlard RD, Hooper JNA. 1997. The first incidence of clionid sponges (Porifera) from the Sydney rock oyster *Saccostrea commercialis* (Iredale and Roughly, 1933). Aquaculture. 157:173-180.

Woods CMC, Floerl O, Hayden BJ. 2012. Biofouling on GreenshellTM mussel (*Perna canaliculus*) farms: a preliminary assessment and potential implications for sustainable aquaculture practices. Aquacult Int. 20(3):537-557.

Wybourne B. 2013. Defensive acontia of the white-striped anemone (*Actinothoe albocincta*) from New Zealand King Salmon Clay Point salmon farm. Report prepared for NZ King Salmon Company Ltd.: Skretting.

Yoneshigue-Braga Y, Baeta Neves MHC. 1981. Preliminary studies on mass culture of *Gracilaria* using different nutrient media. In:Levring T, editor. Proceedings of the Tenth International Seaweed Symposium. Berlin (Germany): Walter de Gruyter; p. 643-648.