Seaweed diseases and pests

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Introduction

Similar to arable crops, cultivated seaweeds are susceptible to diseases that can cause dramatic declines in biomass production and consequently lead to economic losses. Despite the recent growth of the sector in Europe, diseases in European seaweed aquaculture have rarely been studied and reports on this topic are scarce. However, as seaweed farming is advancing in the North Sea, it becomes necessary to assess the potential risks related to pests and diseases and to determine disease management strategies based on experiences from locations elsewhere in the world. In this factsheet, we present an overview of seaweed diseases and proposed risk management strategies.

Economic losses caused by disease outbreaks in Asia

About 10% of the biomass of *Pyropia*, an edible seaweed used to wrap sushi rolls, are lost on average every year in Japan and Korea due to diseases. Between 2012 and 2013, an outbreak of *Olpidiopsis* disease in Korean *Pyropia* farms resulted in a US$1.6 million loss. This was followed by an outbreak of another disease between 2013 and 2014, that caused an approximate loss of US $1.1 million. Similarly, a disease outbreak on the Philippines caused a loss of 15% of the biomass of *Kappaphycus alvarezii*, one of the most important commercial sources of carrageenan, between 2011 and 2013, resulting in an economic loss of over US$ 310 million.

Glossary

Disease: Disorder of structure or function of an individual in response to biotic or abiotic factors which produces specific symptoms and is not the result of a physical injury

Host: Organism on or in which a pathogen or parasite lives

Pathogen: Organism that causes an infectious disease

Pest: Any troublesome or invasive organism causing nuisance, harm or damage to crops

Symptom: Visible or detectable feature which serves as evidence of disease or physical disturbance

Overview: Seaweed diseases and pests

Seaweed diseases can be divided into non-infectious and infectious diseases. Non-infectious diseases are caused by unfavourable environmental conditions, such as changes in temperature, salinity or light intensity. Furthermore, anthropogenic activities like heavy metal pollution, can cause diseases in seaweeds. Symptoms caused by non-infectious diseases are diverse: High temperature and light intensities, for instance, can lead to bleaching and hardening of the algal tissue. But most importantly, seaweeds which are stressed and weakened by unfavourable environmental conditions are more susceptible to infectious diseases. The latter are caused by pathogens. They may either be found inside of the hosts' tissue or on their surface. The following organisms have been described as pathogens in seaweeds:

- Bacteria

Bacteria often act as secondary pathogens, i.e. a bacterial infections occur in seaweeds that are already stressed by unfavourable environmental conditions. The commercially most important disease caused by bacteria is Ice-Ice in the tropical red alga *Kappaphycus* (Fig. A). Ice-ice disease has occurred in almost every location where *Kappaphycus* is cultivated and due to its devastating effects can eliminate entire production sites. Infected seaweeds lose their pigmentation and are gradually consumed and degraded by the bacteria. Other symptoms of bacterial diseases include gall formation and proliferating tissue (e.g. in *Chondrus crispus*, a species of commercial interest in the North Sea). Bacterial infections also occur in other aquaculture-relevant species from the North Sea, as for instance the rot disease in *Laminaria* species and the green spot rot in *Undaria pinnatifida* which cause similar symptoms as described above.

- Oomycetes

Oomycetes, also known as water moulds, are filamentous protists that do not only cause severe diseases in land crops, but also in different commercially cultivated seaweeds. The oomycetes *Olpidiopsis* and *Pythium* have been identified as pathogens in *Pyropia*. Symptoms start with an initial bleaching of the tissue and at later stages lesions and holes (Fig. B), before they finally lead to the

death of infected host. Overall, these infections decrease the biomass and product quality, thereby causing severe economic losses. Oomycete infections have also been described in commercially interesting seaweeds occurring in the North sea, such as *Chondrus crispus*, *Palmaria palmata* and different kelp species.

- Filamentous algae

Seaweeds can also be infected by filamentous algae that either live on their surface (epiphytes) or inside of their tissue (endophytes). Algal epiphytes are a common pest in European kelp aquaculture, but they are also found on red seaweeds. Similar to bacterial diseases, epiphyte outbreaks often occur after drastic changes in temperature or salinity conditions. As epiphytes can cover the entire surface, they prevent a sufficient light uptake by the host. Consequently, the seaweed growth and biomass production decreases, leading to economic losses. Furthermore, seaweeds that are weakened by epiphyte infections are more susceptible to attacks by secondary pathogens, such as bacteria. Endophytes can have an equally devastating effect. Kelps that are infected by the endophytes *Laminariocolax* or *Laminarionema* show various symptoms including galls (Fig. C) and severe thallus deformations (Fig. D) that may cause a loss of biomass or lower the market value of the crop significantly.

- Other organisms

Further seaweed pathogens include cyanobacteria which can build a felt on *Pyropia* that ultimately leads to a degeneration of the host tissue. Amoeba can perforate the cell walls of *Gracilaria*, a red seaweed used for agar production, causing symptoms that resemble the Ice-Ice disease. Diseases are also caused by diatoms (e.g. diatom felt disease in *Porphyra*), viruses (e.g. Green spot disease in *Porphyra*/*Pyropia*) or fungi (e.g. Chytrid blight in the kelp *Undaria pinnatifida*, a commercially relevant species in the North Sea). Symptoms vary from colour loss over disintegration to the death of the host. Epiphytic animals, such as bryozoans, amphipods, gastropods or bivalves are also sometimes regarded as a pest in seaweed aquaculture. While they feed on the seaweed or use it as a substrate, animals can cause severe damage to the algal tissue and lower the biomass production.

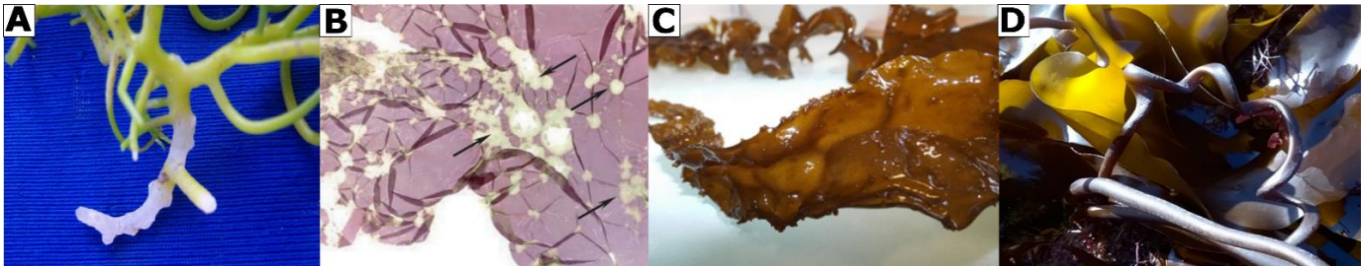
Disease Management & Future research

Various methods for disease management have been proposed and tested more or less successfully. A common method to eliminate pathogens in the tropical Asian regions is acid washing of the algal biomass. Other chemical treatments include the use of iodine or high-nitrogen containing medium. These treatments can not only have side effects on the seaweed biomass, but may also cause serious environmental pollution and are therefore not recommended for common practice in the North Sea. Disease management can also be based on mechanical methods. For instance, exposing the culture ropes/nets to air is a common method to treat bacterial infections. However, overall the recommended protocols for disease management are often either rudimentary or too expensive to be applied by small farmers.

A main focus for seaweed farming in the North Sea should be put on **preventive methods**: Keeping the stock cultures clean without external contamination reduces the risk of transferring pathogens to the production site. Furthermore, decreasing the culture density can help to prevent disease outbreaks. In times of high light intensity, culture ropes may be moved to lower depths to avoid excessive light stress. In land-based seaweed aquaculture, special attention should also be paid to avoid drastic changes in salinity and temperature. Moreover, the frequency of water flushing and agitation can be optimized to restrain disease outbreaks in land-based systems before drastic biomass losses occur.

New diseases have been reported frequently over the last years, but overall, the epidemiology of seaweed diseases remains largely understudied. In addition, disease outbreaks are predicted to become more frequent in the future under the impact of climate change. It is therefore necessary to develop low-cost monitoring systems and innovative management strategies as well as disease-resistant strains to facilitate and ensure a sustainable development of seaweed aquaculture in the future.

Figure: A. Ice-Ice disease in *Kappaphycus*, Philippines (©Ronald Simbajon). **B.** *Pyropia* infected by an oomycete, Korea (Kim et al. 2014, Algae). **C.** Galls in *S. latissima*, infected by endophytic brown algae, France. **D.** Twisted stipe of *L. digitata*, infected by endophytic brown algae, France.



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