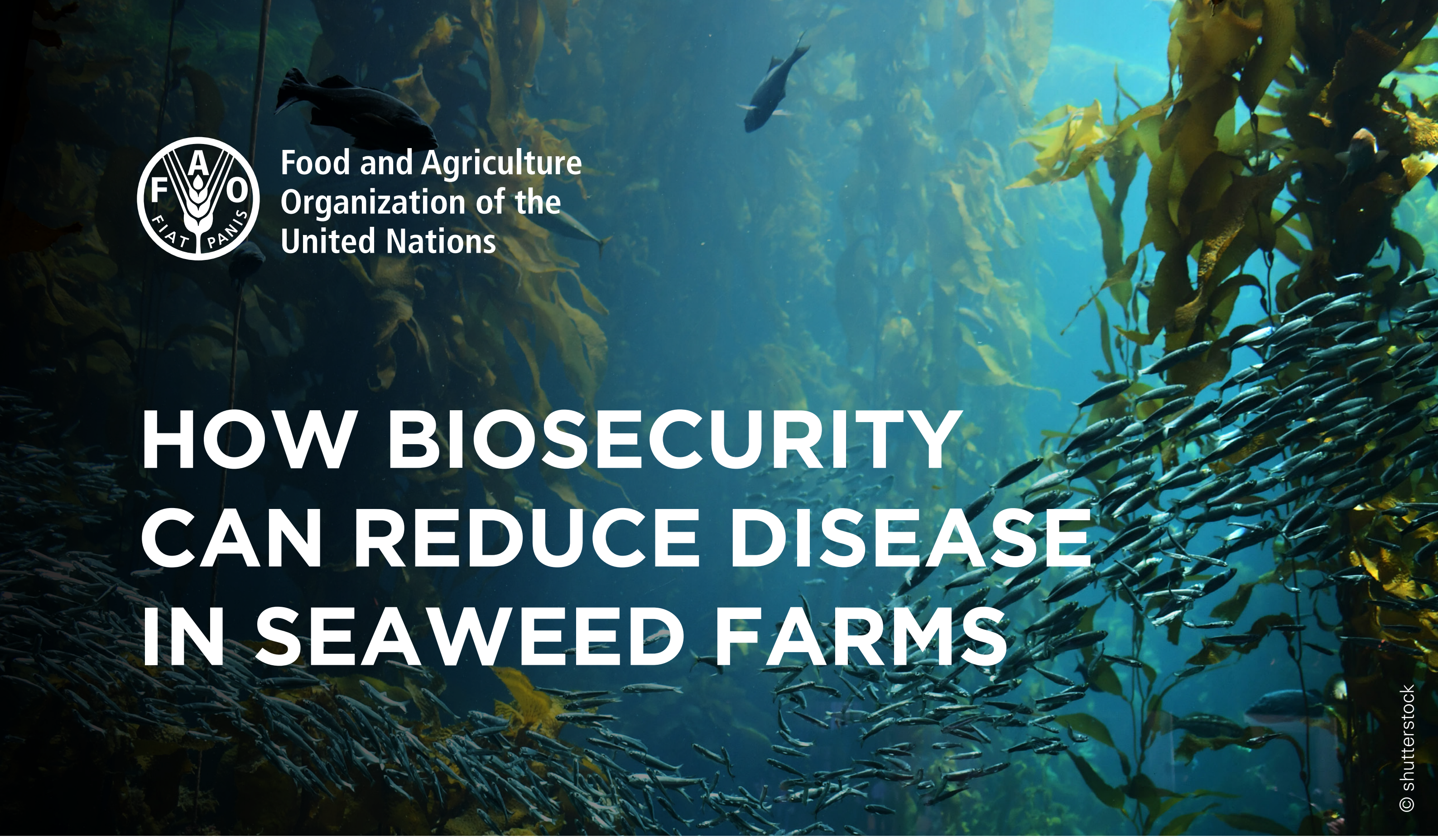
Food and Agriculture Organization of the United Nations



HOW BIOSECURITY CAN REDUCE DISEASE IN SEAWEED FARMS

A research study in Malaysia has shown that basic biosecurity measures can help to significantly reduce the incidence of diseases such as ice–ice syndrome occurring in seaweed farms.

The majority of seaweed production in the world came from farming in East and Southeast Asia. Between 2000 and 2018, the global farmed production increased more than tripled from almost 11 million tonnes to 32 million tonnes (worth USD 14 billion) (FAO, 2020). The main farmed species, Japanese kelp (*Laminaria japonica*), *Eucheuma* spp., *Gracilaria* spp., Wakame (*Undaria pinnatifida*), *Porphyra* spp. and *Kappaphycus alvarezii* contributed more than 80 percent of world seaweed production.

Seaweed is rich in micronutrients, including iodine, iron, zinc, copper, selenium, fluorine and manganese, as well as vitamin A, vitamin K and fibre. It is the only non-animal source of vitamin B12. Seaweeds containing sulphated polysaccharides increase the growth of beneficial gut bacteria (Lopez-Santamarina, *et al.*, 2020). Studies showed correlations between high seaweed consumption in Asia and reduced risks of cardiovascular disease, cancer and diabetes, as well as a positive correlation between seaweed consumption, iodine intake and life expectancy (Brown *et al.*, 2014).

Some species such as *Undaria pinnatifida, Porphyra* spp. and *Caulerpa* spp. are produced primarily as human food. The rapid growth in the farming of *Kappaphycus alvarezii* and *Eucheuma* spp. in Indonesia as raw material for carrageenan extraction has been the major driver in the increase of farmed seaweed production in the past decade (FAO, 2020). Seaweed is also processed by the food industry for use as polysaccharide additives and functional food ingredients. Hydrocolloids, which are extracted from seaweeds, have both food and non-food uses – with products destined for nutraceuticals, pharmaceuticals and cosmetics, and to a lesser extent as organic fertilizers, biofuels, biodegradable packaging for food, bioplastics and other industrial outputs (Barbier and Charrier, 2019).

Besides direct contributions to nutrition and food security, seaweed and aquatic plant production systems can improve fish habitats, increase marine biodiversity and contribute to ocean restoration, sequestering carbon and improving water quality, thereby promoting more sustainable food production systems. Integrated multitrophic aquaculture studies conducted in China suggest that large-scale culture of seaweed reduces nitrogen levels and limits the frequency of toxic algal blooms (Xiao *et al*., 2017).

Seaweed extracts have antibacterial properties and can be used to reduce and replace antibiotic use in both terrestrial and aquatic animal production systems. A review by Ghosh, Panda and Luyten (2021) on the inhibition of *Vibrio* spp. in shrimp found that extracts from *Gracilaria* spp. and *Sargassum* spp. had the most potential.

Scientists have also found that the red seaweed genus, *Asparagopsis*, produces high levels of bromoform, a halogenated compound. When freeze-dried and mixed at inclusion levels of 0.2 percent in cattle diets, this reduced the cattle's methane production by up to 98 percent and simultaneously improved their weight gain by 42 percent (Kinley *et al*., 2020).

Despite all the potential nutritional, industrial, environmental, economic and employment benefits of seaweed aquaculture, seaweed productivity is declining in many areas of the world because of climate change impacts such as increasing ocean water temperatures and variations in salinity, as well as human-induced environmental impacts such as eutrophication, which are resulting in more frequent seaweed disease outbreaks.

Ice–ice syndrome has become a major problem for the seaweed industry, particularly in the hot dry season, where whitening or discolouration of the old thallus causes fragmentation and degradation of red seaweed quality. Ward *et al*. (2020) identified seawater temperature elevation, variable salinity and the presence of such seaweed pests as epiphytic microalgae as the key factors that make red seaweeds more susceptible to ice–ice syndrome.

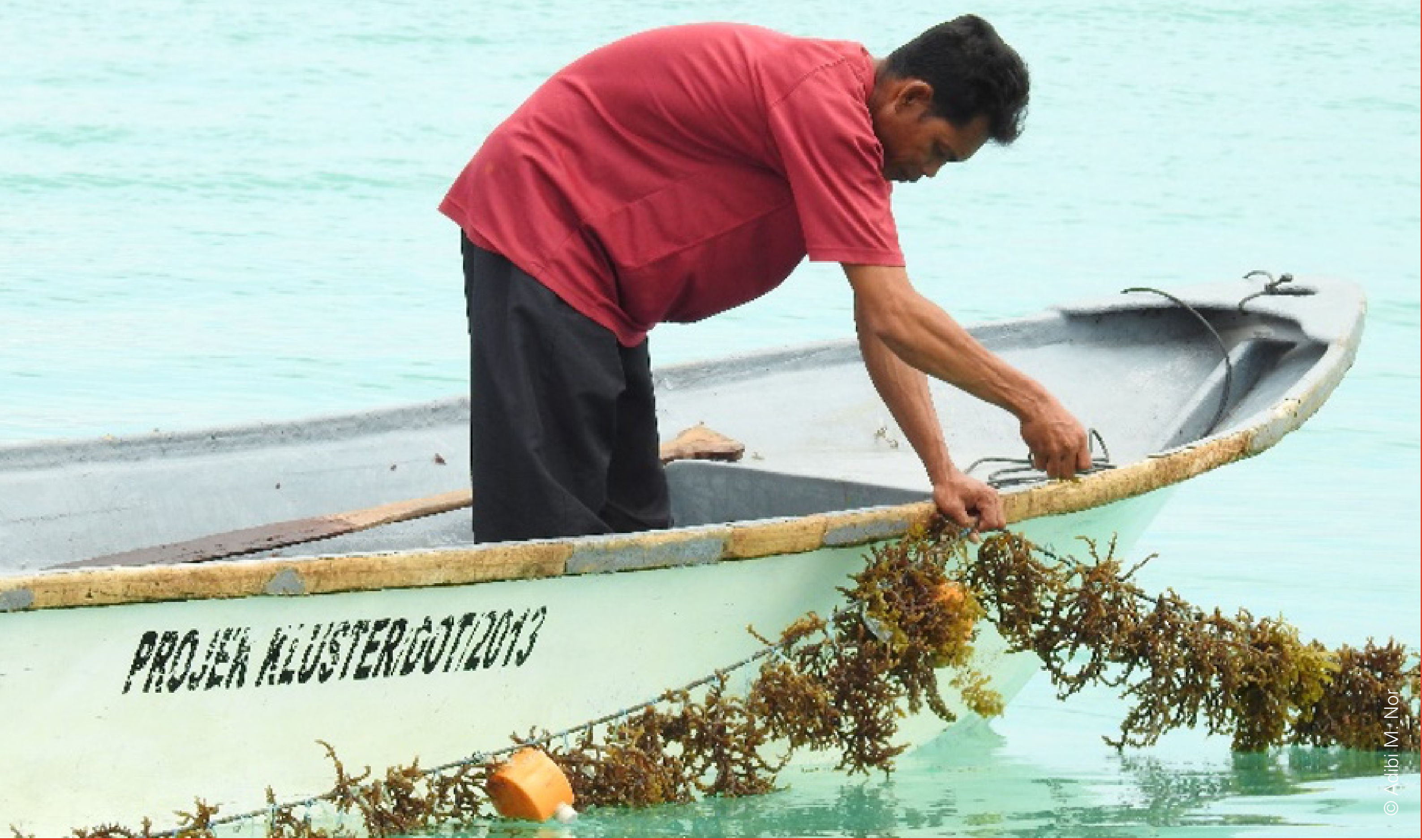
While biosecurity protocols to minimize the likely risk of introduction and spread of disease pathogens and pests are applied to the production of most aquatic fish and shrimp species, they are not generally applied to seaweed production.

Women's participation in seaweed farming as a household enterprise

SCOPE AND SCALE OF APPLICATION

In Malaysia, the Department of Fisheries has produced guidelines on the cultivation of *Kappaphycus* and *Eucheuma* with some general biosecurity recommendations, there has been minimal uptake by the industry because of limited stakeholder consultation and awareness (Nor *et al.*, 2020).

Kambey *et al.* (2021) conducted a 40-day research study from 18 June to 28 July 2019 at Gallam-Gallam Village, Bum–Bum Island, Sabah, Malaysia. The trial compared the growth, production, survival, disease incidence, carrageenan yield and gel strength of *Kappaphycus alvarezii* and *K. malesianus* grown on longlines on two adjacent farms, 500 metres apart. The only difference between the two farms was that the control farm followed normal local culture procedures with no biosecurity measures, while the pilot farm was operated with basic biosecurity measures. The results of the trial are discussed subsequently in this brief.



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Manual cleaning of seaweed by a seaweed farmer

COMPLEXITY AND ACCESSIBILITY

The implementation of a seaweed biosecurity system requires assessment of the potential entry points into a culture system for disease pathogens and pests and then the development of protocols to minimize the potential entry points for pathogens. Having developed a biosecurity protocol, it is important to train all farm staff on operating principles and to have a management system in place that ensures its implementation.

Application of a basic seaweed biosecurity system is technically simple and, if appropriate extension and training materials or practical training are available, seaweed producers of any scale should be able to adopt one.

The key issue about ensuring basic seaweed biosecurity is that it requires additional time and labour to implement, but these investments are offset by the results.

TECHNIQUE AND APPROACH USED

The following key basic biosecurity measures were tested by Kambey *et al.* (2021) for seaweed culture in Sabah, Malaysia:

The boat was cleaned and sun-dried before use.

Approximately 15 kg of seaweed propagules, collected as cuttings, were transported in a cool box for about one hour from a farm in an area where disease outbreaks were low in the trial village and the seaweed was assessed by the Department of Fisheries as being of good quality.

On arrival, all propagules were visually checked for bleaching, discolouration, wounds, epiphytes, epi-endophytes, biofilm, biofouling and any other unwanted material. No substandard propagules were used for the trial and all substandard propagules were removed from the farm and discarded in a landfill site.

All culture ropes, longlines, propagule tie strings and floating buoys were new.

Every two days the seaweed strings were checked, cleaned and epiphytes/epi-endophytes, biofilm, fouling and all attached wastes were carefully removed manually from the crop and the ropes (using tissue paper or soft fabrics). Bleached/discoloured thalli were removed from the farm by detaching each bleached thallus.

All bleached/discoloured thalli, epiphytes/epi-endophytes, biofilms and waste materials were gathered and discarded in a landfill. No wastes were discarded within the farm area.

Water quality parameters, measured at 09.00, were monitored every three to four days. These included water temperature, salinity, pH, inorganic ammonium and nitrate.

Every 10 days the seaweed strings were checked, growth was measured, pest coverage was assessed and ice–ice incidence was recorded.

THE OUTCOME AND BENEFIT

Compared to the control farm, ice–ice incidence on both *K. alvarezii* and *K. malesianus* was lowered threefold at the seaweed farm following basic biosecurity measures. Ice–ice incidence was detected earlier and affected more propagules at the control farm. Up to 96 percent of the propagules in the biosecure farm were disease free after 40 days of culture.

The average epiphyte coverage was statistically (Kruskal–Wallis $p < 0.05$) lower for the farm following basic biosecurity protocols compared to the control farm. Regular removal of the main seaweed pests, like macroalgae epiphytes and filamentous epi-endophytes, reduced the load of ice–ice syndrome causative agents in the farm environment.

The carrageenan quality and the gel strength of healthy seaweed thalli from the biosecure farm were higher than the control farm for both *K. alvarezii* and *K. malesianus*. However, the difference was not statistically significant. Ice–ice infected and uncleaned thalli had a 10 percent to 14 percent lower carrageenan yield and 16 percent to 45 percent lower gel strength compared with healthy seaweed thalli from the biosecure farm (Kambey *et al.*, 2021).

The specific growth rate of both *K. alvarezii* and *K. malesianus* was higher at the biosecure farm, reflecting less seaweed thalli damage caused by disease and pests.

Seaweed farmers are unlikely to buy new equipment when starting a seaweed crop. Therefore, Kambey *et al.* (2021) recommended an extended period of sun drying to reduce pathogen loads. Further study is required to confirm that increased labour costs for biosecurity implementation are offset by increased production and seaweed quality (carrageenan and gel strength) in other areas of the world besides Malaysia.

Biofilm 'white mucous' on a green strain of *Kappaphycus striatus* seaweed

Biofilm 'white mucous' on a brown strain of *Kappaphycus striatus* seaweed

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