Brief for GSDR – 2016 Update

A Horizon Scan on Aquaculture 2015: Management Practices

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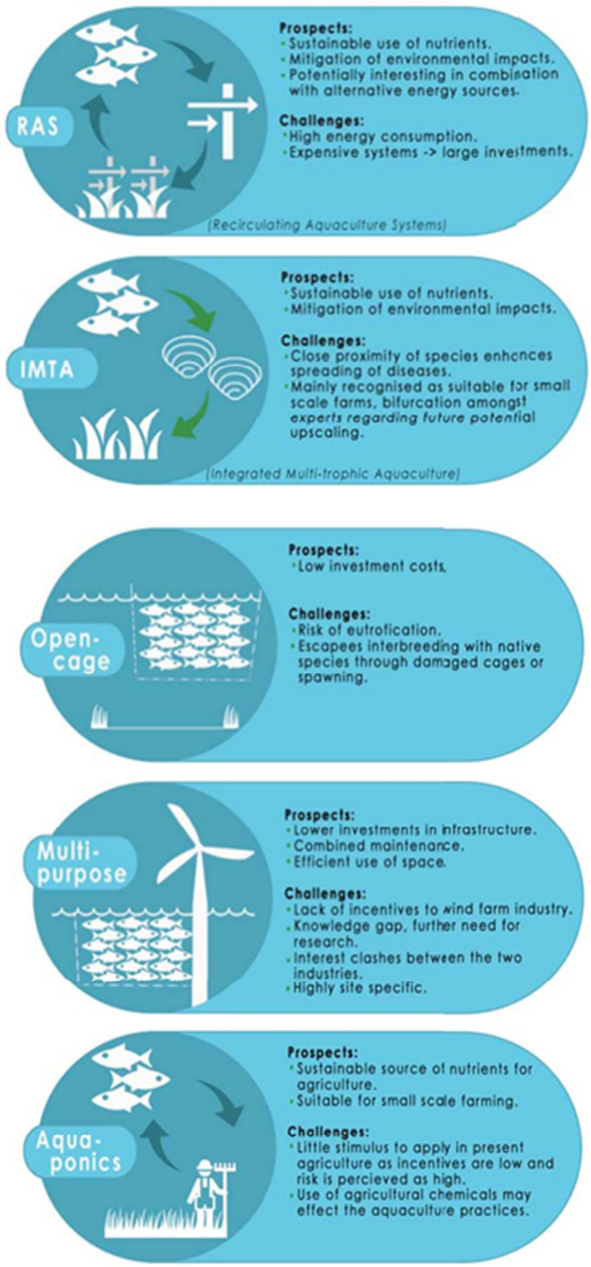
Globally, a wide range of different management practices are used in aquaculture. The organization of aquaculture farms and which methods and technologies are used determine their impacts on the environment, and varies considerably throughout the world.

This policy brief focuses on the targets, tools and threats of management practices. The three tools of production methods automation and selective breeding and GMOs are explained, their targets and threats made clear. After the tools there is more elaboration on the threats of diseases and medicine, escapees and water quality.

Production Methods

Over the past decades the development of alternative more sustainable cultivation systems in aquaculture has been given high priority. The reuse of nutrients is a potentially high impact method. Nutrient recycling creates a cyclic method by using the waste of one species as the input for the other. Shellfish cultivation can play a large role in this, like in IMTA (Integrated Multi-Trophic Aquaculture) [1, 2]. It has led to some successes on a small scale level, but so far has not been proven viable for upscaling and industrialization.

The main targets of the production methods mentioned are to achieve sustainability and overall efficiency. This could be efficiency in the use of nutrients as is the case with IMTA and RAS (Recirculating Aquaculture Systems), but also space efficiency in for example multi purpose offshore. Multi purpose off shore aquaculture attempts to



[1] A collaboration between Wageningen University and Research Centre (WUR) and the State University of New York (SUNY) College of Environment Science and Forestry.

combine cultivation practices with energy generating, using the same infrastructure.

The infographics illustrate the most important production methods and briefly point out their prospects and challenges. A bifurcation amongst scientists seems to occur. One group promotes further research in multi-trophic cultivation systems to make it suitable for upscaling, the other is convinced that even if it were to be found practically viable, economically it would not function. The incentives to deviate from current practice and to source nutrients elsewhere is too low considering the risk involved [3]. Monoculture systems at present are more profitable than polyculture systems and require less effort. This is however not the case in small communal cultivation practices where Aquaponics systems and IMTA schemes successfully could be used for sustainable cultivation.

Threat

One of the main threats posing the cultivation of fish in farms is the spread of disease. The fish are kept in 'un- natural' close proximity of each other, which enhances the possible outbreak of epidemics. The contemporary solution in many countries is still the administration of antibiotics; excess use however poses a serious threat to food safety and thus, human health. A more responsible alternative is preventative medicinal use like probiotics and vaccines.

Automation

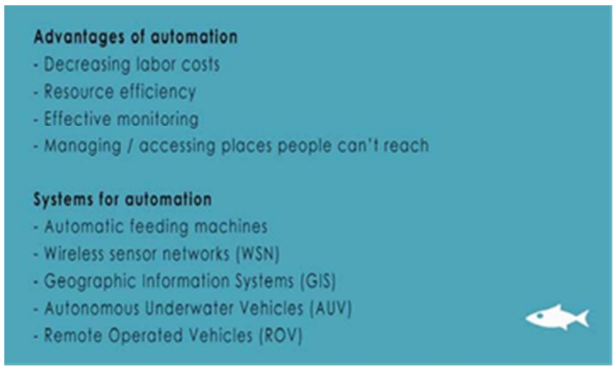
Automation is a management practise that is especially useful in countries where labor costs are high [4,5]. The main target of automation is to increase efficiency in the production process. The improved technology also contributes to mitigating environmental effects and therefore improves the sustainability of a farm. The feeding process has already been automated at larger farms for an efficient fed diet.

Tools for automation are mentioned in the textbox. All can contribute on decreasing labor costs, effective and efficient monitoring, management and accessing remote places [6].

Poor water quality is an important threat to aquaculture that has a strong relationship with technology and automation. Organic waste like leftover fish feed can affect the water quality as well as environmental conditions like pH and dissolved oxygen. These effects can be monitored more efficiently with automated technology and thereby mitigating the negative impacts.

Prospects of automation

There are several reasons why automated systems are not being used yet on a more global scale. These are: (1) accessibility to the technology; (2) no market; (3) low labor costs in some regions that reduce the return of in- vestment of automation [3]



Selective Breeding & Genetically Modified Organisms (GMO)

Selective breeding

Selective breeding is the deliberate mating of animals with specific desirable traits. The main target for both selective breeding and GMOs is increasing the yield. Specifically, salmon has been a success in selective breeding[8,9,10]. The genetically improved farmed tilapia (GIFT) also has been applied throughout the world, especially in Asia [9]. Breeding programmes can hold a lot of potential, like improved growth and disease resistance. Upscaling has not yet occurred

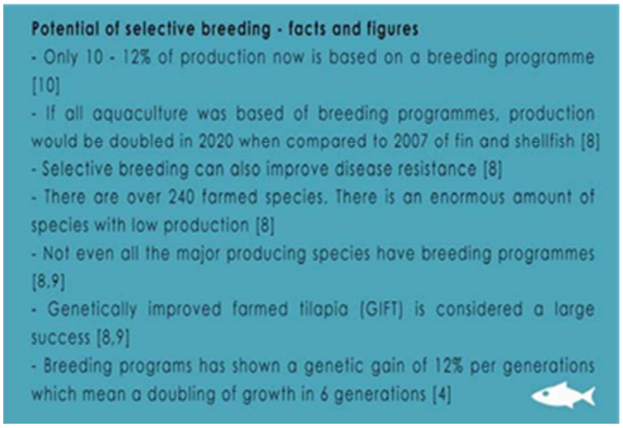
because efficient breeding programs are capital intensive and small scale farmers may not be willing to invest in improved breeds [11]. For low production species breeding programmes are also not feasible. Some countries are also against using through selective breeding improved strains because they could be different from their native strains.

Threat

A threat in aquaculture that is closely linked to selective breeding are escapees. Genetically improved farmed fish can show aggressive behavior towards wild fish and possibly affect the wild strain [12].

Prospects of selective breeding

The future development of selective breeding depends on many local and international factors. One important challenge is the high number of aquaculture species farmed [13]. Under the most optimistic scenario at least one breeding program would be developed for each species. The highest returns would be gained by focusing on establishing breeding programs for the species with the highest production and value [9].

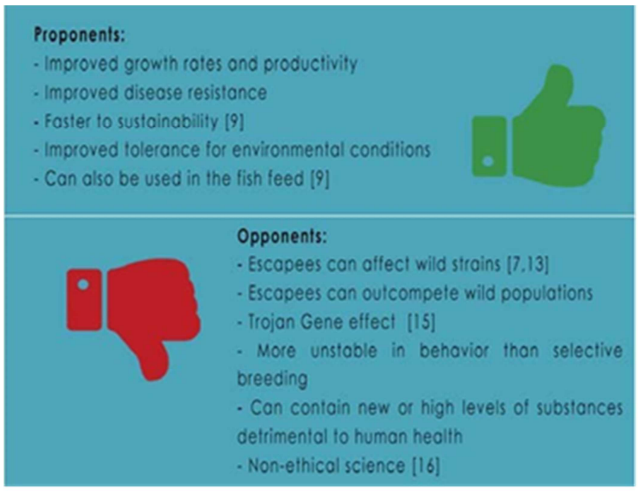


GMOs

The use of GMOs in aquaculture industry is at this moment not generally accepted globally, mostly as a consequence to the controversy surrounding the topic and the consumer power. In the figure below the arguments of proponents and opponents for GMOs in aquaculture are stated.

Threat

There are great concerns with GMO escapees. These escapees could outcompete wild populations [14] or even wipe them out entirely by the Trojan Gene effect [15]. They are also viewed as being more unstable in their behavior than selective bred farmed fish.



Prospects of GMOs

The discussion about GMOs will most likely increase when the aquaculture sector will take an even larger position in the world food market. Large producing countries can have a big influence on this subject.

THREATS

Diseases and Medicine

A major threat to aquaculture is fish disease, in particular epidemic diseases [17]. A rapid widespread outbreak of any infectious disease could jeopardize an entire industry. The amount of prevention measures could also carry implications regarding food safety and environmental responsibility. In recent decades a number of reference cases have unfolded in which a farmed species and its industry got

affected with a disease. As a response to these events, it has lead to less sustainable practices in that sector [18]. These diseases could also gravely impact wild populations.

Antibiotics are used to fight pathogens and work as growth promotants, yet have many negative effects on the environment and human health. As awareness of the effects on human immunity arose, regulations were set in place and the rising trend of antibiotics use reversed. A focus on preventative measures has received higher attention amongst academia, the aquaculture industry as well as in the pharmaceutical industry. Norway has taken the lead in diminishing the use of antibiotic, however, in other parts of the world it is still in development.

At present focus lies on utilization of probiotics, vaccines and less stressed animals. Especially vaccines are now common practice for some species [10]. The challenge is to make species specific solutions to obtain the desired results.

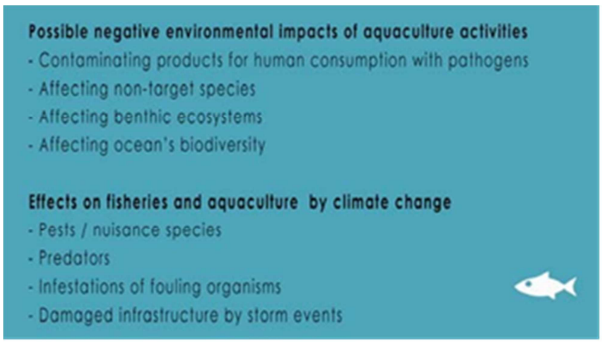
Preventive measures however face the restraint that farmers cannot always predict when the onset of disease would occur and therefore anticipation is difficult. Raised awareness, certification schemes and legislative regulation combined steer for the decline in use of antibiotics. This trend however is globally not evenly covered.

Escapees

With offshore marine aquaculture the risk of fish escaping from pens could increase, as conditions are much rougher in the open ocean [12]. Management practices should encourage better design, installation and operation of offshore marine aquaculture farms to reduce the overall number of escapes. Monitoring of fish movement is also important to reduce escapees. It is also imperative that management practices support better risk assessment of non native species; it is important that there is thorough understanding of escape risk on a per species basis, wild spawning sites and migration routes. This will enable farms to be sited better, away from sensitive areas. Existing research on escapees is heavily weighted towards Atlantic salmon, and there is still little information on the potential effects of inter-breeding for most other species. Applying alternative methods to managing escapees should also be considered, for example by producing sterile triploidy specie, or reducing species their fertility, to eliminate opportunities for breeding with wild populations [19]. In the figure the causes, effects and possible prevention techniques of escapees are listed.

Water Quality

Good water quality is essential for the long term viability of aquaculture farms, and will become even more important as the number of farms and their environmental impacts increase.



Water quality is affected by organic waste, (fish feed) nutrients, diseases, pharmaceuticals, pesticides, and antifoulants (toxic paints). The water quality could also be affected by other industries close to aquaculture sites [20]. In the figure the possible negative impacts of aquaculture activities are listed. In order to minimize the negative effects of these factors on the quality of water, as well as benthic ecosystems, it is important to enforce management practices that take these factors into account. These help to mitigate environmental risks by managing complex ecological interactions [21]. Management practices should also help to mitigate the adverse effects of climate change, which has a negative effect on aquaculture. Increased storm events could for example damage aquaculture infrastructure. Implementation and enforcement of better management practices is critical to mitigate these high impact threats.

Future Prospects

- Selective breeding has large potential. Only 10-12% is based on breeding programmes [11, 22], so there is a lot of space for improvement. Sound government policy could facilitate research on high-production species that are currently working without a breeding programme. Research suggest there is much to be gained that would deliver return on investment.

- Escapees and preventive solutions should get more attention from policy makers, as it is an abiding problem within mariculture especially. The number of escapees is likely to increase parallel to the expansion of mariculture. Implementation of preventative measures should be adopted as standard practice.
- Preventive medicines deserve priority because treatment of diseases could potentially harm humans through the consumption of the end product, contaminated by medicinal residues.
- Awareness on fish welfare is a consumer driven demand that is expected to call for changes in cultivation practices.
- The debate on GMOs should not be restrained by preconceived ideas but open and evidence based. The results of this debate could be very influential for aquaculture on a global scale. Acceptance of GMOs in European markets will be challenging, but if GMOs are accepted in large production countries in Asia, this could have substantial effects on the world aquaculture market.