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Can stock enhancement enhance stocks?

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Abstract

Successful stock enhancement or restocking requires a thorough understanding of the ecological processes that provide a potential for stocking within different ecosystems, i.e. determine which factors define the potential for stocking, such as population dynamics, economic cost-benefits, fisheries management and socio-economic impacts. Stocking is not simply a question of aquaculture logistics (i.e. the ability to produce a sufficient number of fry relative to the magnitude of the natural recruitment within the system), nor should it be a new outlet for aquaculture production. Quantitative targets should be set and the expected performance of the stocking tested. Potential loopholes, such as post-release mortality and habitat requirements related to the release, should be examined and resolved. If properly managed, stocking may lead to an increase in population, contribute to the local fishery and/or lead to an increase in the spawning stock biomass. The criteria for stocking are discussed in this paper using examples from flatfish and cod stocking programmes within specific ecosystems.

Keywords: Stocking; Stock enhancement; Flatfish; Turbot; Cod

1. Introduction

The decline in many commercially important fish stocks has speeded up the search for improved management tools, including the shift towards ecosystem-based fisheries management, the introduction of Marine Protected Areas (EC decision on the Common Fisheries Policy [EC/2371.2002]; ICES, 2004a,b) or closed boxes such as the 'plaice box' in the North Sea (ICES, 2004b) to protect fish populations during critical life-stages. These management regulations have, however, proved difficult to apply and have achieved limited results. The genetic implications are barely understood and socio-economic aspects need to be incorporated. Common to these management approaches is restriction of an activity that will, at best, allow the fish population to proliferate by removing one of its pressures. However, for stocks under multiple pressures where major environmentally induced bottlenecks for recruitment are compounded by overfishing, slightly reducing the fishing pressure may be insufficient to improve conditions within management or political timeframes. In some cases, stock enhancement or restocking may offer the opportunity for proactive action. Stock enhancement is here defined as repeated releases of fish to even out natural fluctuations in recruitment and thus stabilise the fisheries. In the literature this is also referred to as sea ranching. Restocking is here defined as multiple releases of fish to a stock chronically suffering from poor recruitment with the aim of increasing both fishery recruits and the spawning biomass. For stocking to

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actually result in an increase in recruits or spawning stock biomass, the scientific approach must be appropriate. It should take into account both major environmental drivers and genetic, socio-economic and management aspects, and implications for the particular species within the ecosystem in question (Blankenship and Leber, 1995; Støttrup, 2004).

Embracing stocking as a tool in fisheries management requires a thorough understanding of the ecological processes that provide a potential for stocking within different ecosystems. The potential for stocking is not derived solely from whether or not the species can be cultured in sufficient quantities relative to the magnitude of the natural recruitment, although ultimately this may be important. The potential for stocking is primarily related to the population dynamics of the species within a given ecosystem, economic cost-benefits, fisheries management and socio-economic impacts. The expected performance of stocking should be tested against quantitative goals as was also suggested by Bannister and Howell (2005), and specific problems such as post-release mortality should be examined and resolved (Furata, 1996). There is a need to explore the potential for utilising stocking to sustain natural stocks that are under pressure due to adverse natural or anthropogenic environmental conditions. This is already the case for some species. For example the International Council for the Exploration of the Sea (ICES) has recently changed its views on stocking and now recommends large-scale stocking of European eel *Anguilla anguilla* as a long-term measure to preserve that population (ICES, 2005).

The criteria for stocking are reviewed and discussed in this paper using examples from flatfish and cod stocking programmes within specific systems to illustrate these criteria and highlight differences. The genetic consequences of stocking also need to be taken into consideration but are not discussed in this paper. A review on this issue is provided by for example Cross (1999).

2. Aims of stock enhancement and restocking

Stock enhancement is employed to even out the natural fluctuations in recruitment thereby stabilising the fisheries. The Japanese stock enhancement programme running since 1963 is an example of stock enhancement with an annual production of 32 different species of fish, shellfish and other invertebrates (Imamura, 1999). The Norwegian cod *Gadus morhua* stocking programme (1990-1997) is another example of stock enhancement (Svåsand et al., 2000). Also referred to as sea ranching, the release of fish is expected to increase the numbers recruiting to the fisheries, especially during years with poor supply of juveniles to the nursery grounds. It implies that the recruitment bottleneck occurs prior to the nursery life-stage and that there is ample prey and few predators during the juvenile stage.

Restocking can be applied to stocks that are chronically suffering from poor recruitment and where the spawning stock biomass is well below the Biological Safe Limit set for that stock (sensu ICES, 2004a). In such cases stock recovery is urgent. The aim of restocking is to increase fishery recruits as well as to increase the spawning stock biomass. Restocking should be part and parcel of fishery management, including recovery plans, for depleted stocks.

3. Criteria for stocking

Stocking, whether for enhancement purposes or restocking, cannot always be successfully applied and there are several criteria that need to be fulfilled before stocking can be a potential tool for enhancing recruitment to fisheries:

1. There should be a *distinct* recruitment bottleneck, not primarily due to overfishing.
2. There should be ample (excess) food for the released fish and following life-stages.
3. There should be a low predation pressure for the size released and larger fish.
4. There should be an economic cost-benefit, or at least quantifiable objectives for this.

Each of these criteria will be dealt with separately, illustrated by results from releases for stock enhancement purposes of flatfish in Denmark (Støttrup et al., 1998, 2002), or cod in Norway (Svåsand et al., 2000), or from a theoretical study on the potential for restocking the Eastern Baltic cod in ICES Subdivision 25 (Støttrup et al., 2005a,b).

3.1. Recruitment bottleneck not primarily due to overfishing (stocking criterion no. 1)

In most temperate flatfish species, recruitment is believed to be limited during the pelagic stage (Van der Veer et al., 1991; Henderson, 1998), or during or just after settling (Tanaka et al., 1989; Rijnsdorp et al., 1992; Gibson, 1994; Van der Veer et al., 2000). High predation pressure during the egg and larval stages, starvation during the early larval stage, and poor supply to the nursery grounds due to adverse wind and current conditions may result in the nursery areas being