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Quality of hatchery-reared juveniles for marine fisheries stock enhancement

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Abstract

The potential for stock enhancement by release of hatchery-reared juveniles continues to be a topic of interest to researchers and fisheries managers. While, in many studies, the focus has tended to be on the technology for production of juveniles, the need for a more multidisciplinary approach is now becoming accepted. Ideally, this includes studies of population dynamics and recruitment-limitation of wild stocks, environment–stock interactions, habitat availability, genetic studies of wild and released stocks and integration with appropriate fisheries management. While it may be relatively straightforward to culture large numbers of seed animals, the quality of hatchery-reared juveniles may limit the effectiveness of any release programme. The quality of juveniles may be defined either by their ability to attain the age and size to recruit to a commercial fishery or their fitness to survive to contribute to the spawning stock. Many factors will inevitably influence batch–batch variability in the viability of hatchery-reared juveniles and their ability to recruit and compete in the wild. Some effects of nutrition and environment in the hatchery are well-known or at least recognised and their manipulation offers the potential for improvement of survivorship of juveniles post-release. The choice and utilisation of broodstock also represent a crucial stage in enhancement programmes, and considerations of bottleneck effects arising from reduced effective population size due to skewed parental and family contributions must be given careful consideration. A broodstock design that encompasses sufficient numbers of animals that reflect the genetic, and preferably ecological, identity of the stocks to be enhanced should be adopted. In addition, environmental conditions and husbandry practices within the hatchery as well as broodstock and larval nutrition can all influence the quality of offspring. Further conditioning and/or selection during nursery culture may also be critical in maximising the physiological and behavioural fitness of hatchery juveniles post-release. Although evaluation of long-term performance of individual batches of juveniles requires considerable effort or may be impossible in some cases, this type of quantification is likely to be an important component in the determination of the effectiveness of release programmes. This paper reviews the effects of hatchery and nursery practice on larval and juvenile fitness for stock enhancement and presents examples of comparisons of the quality of wild and hatchery-reared juveniles and the effect of pre-release conditioning on subsequent survival and growth.

Keywords: Stock enhancement; Larvae; Broodstock; Genetics; Behaviour

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Contents

1. Introduction

Both coastal aquaculture and fisheries make significant contributions to provision of long-term global food security, that is universal and consistent access to affordable basic food requirements, through supply of seafood and the generation of economic purchasing power (Liao, 2004). However, as human populations increase, particularly in the coastal zone, and the majority of marine capture fisheries reach fully exploited or over-exploited status (Anon, 2004) there seems to be little scope of further increase in supply from natural fisheries in the future (Watson and Pauly, 2001). This shortfall is likely to be particularly critical in coastal regions of developing countries, where seafood is both a major source of dietary protein and an important sector of the economy. In many regions, over-exploitation, loss of habitat and natural and anthropogenic changes in environmental conditions have contributed to a decline in yields (Doi et al., 1969; Imai, 1982; Fushimi, 1999). Development of aquaculture-based fisheries represents a key mechanism to enhance seafood production either through the restoration of depleted spawning stock biomass (restocking), or increasing fisheries yields where the spawning stock is not depleted but recruitment to specific areas or populations is limited and habitat and environmental carrying capacity underutilised (stock enhancement) (Bell, 2004).

Despite the attractiveness of stock enhancement as a management tool and the consequent long history of release programmes dating back over more than a century (Blaxter, 2000) in many cases the benefits are not measurable, due to both the difficulty of quantifying yield and sustainability, and insufficient consideration of the complex factors that may determine success (Bell, 2004; Hilborn, 2004). However, recently the provision of such measures is becoming more effective through adoption of a more integrated scientific approach (Mustafa, 2003; Leber et al., 2004). Guidelines for effective and responsible stock enhancement have been recognised and largely agreed upon by the research community (Blankenship and Leber, 1995) but economic and practical constraints often limit the extent to which these are applied.

The principal issues facing the development of effective stock enhancement include a) integration with appropriate fisheries management, b) understanding of environmental carrying capacity and intra-specific competition, c) improvement in seed quality, ensuring the health status of hatchery-reared juveniles and wild stocks, d) understanding the genetic implications for target stocks and design of appropriate broodstock management, e) development of effective release strategies, and f) quantification of effectiveness at biological and socioeconomic levels (Tsukamoto et al., 1999; Kitada, 1999; Leber et al., 2004). Thus any programme for the development of marine stock enhancement must adopt a multidisciplinary and participatory approach to address all the factors that may influence the likelihood of success and its quantification.

From the aquaculturist's point of view, the production of sufficient numbers of animals for a release programme at the appropriate time of year may in itself be a considerable task. However, it is now clear that the different aspects of hatchery production, from broodstock selection, through larval nutrition to nursery husbandry must also take into account the more