International Council for the
Exploration of the Sea

ICES ASC 2006/H:03
Evolutionary effects of exploitation on living marine resources

Exploitation-induced changes in farmed stocks Pacific oysters along the French Atlantic coast

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Commercial exploitation of living resources may have severe effects on populations and species. Firstly, changes in demographic properties such as population size and age and size structure may leave populations vulnerable to stochastic changes in environmental factors. Secondly, harvesting may induce changes in life history traits. Such changes may be expressed as either immediate plastic responses to environmental variation or adaptive evolutionary change due to changing fitness regimes (Stokes et al. 1993; Law 2000; Stokes and Law 2000; Heino and Godø 2002). During the last two decades, there has been an increasing interest for studying evolutionary changes in stocks of harvested marine species (Law & Grey 1989, Rijnsdorp 1993) and one major task is to separate environmental and evolutionary effects on observed phenotypic changes. Using a suitable model system, the Pacific oyster (*Crassostrea gigas*), we aim to disentangle plastic and evolutionary components of observed life-history changes in a farmed population.

Oyster production represents a considerable part of the local economy in several coastal regions in France and has a current production of about 126 thousand tons a year to a market value of about 160 million euros. The Portuguese oyster (*C. angulata*) was introduced to French coastlines to increase production that had until then been based on the native *Ostrea edulis*. Following the extinction of *C. angulata* 35 years ago, *C. gigas* were massively introduced from Japan and Canada to sustain production. This introduction was entirely under the control of private oyster farmers and did apparently not undergo any governmental supervision or. Life-history data such as growth and timing of spawning has been collected since the introduction and changes in certain life-history traits have been reported. Firstly, there are indications that growth rates have decreased (e.g. Fleury *et al*. 2001). Reduced growth rates lower economic potential of the species and from a commercial perspective there is an obvious interest to reverse such a trend if existing. Secondly, timing of spawning seems to have been delayed (Soletchnik, unpubl) and although delayed spawning may ensure higher fecundity and better egg quality because of more time for energy acquisition, there is a risk that larvae miss the period of optimal environmental conditions for development. Several causes for these changes have been suggested: (1) phenotypically plastic response to changing environmental factors; (2) local adaptation of the species to its new environment; (3) exploitation-induced evolution caused by the size-selective harvest.

The aim of this study is to separate plastic and evolutionary causes of phenotypic changes. By using time series of environmental parameters (biotic and abiotic) to remove noise due to plastic responses in time series of phenotypic traits we may observe temporal trends in residuals and thereby separate the effects of plastic and evolutionary components of the observed changes in growth and timing of reproduction. Whereas plastic responses can be reversed within a generation, backtracking undesirable evolutionary changes generally requires several generations. Investigating the causes of life-history changes is therefore crucial for the selection of correct management strategies to obtain long-term sustainable yields in this species.

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