

Importance of fish biodiversity for the management of fisheries and ecosystems¹

J. G. Hiddink (Univ. Wales-Bangor, UK)², B. R. MacKenzie (DIFRES, Denmark), A. Rijnsdorp (IMARES, Netherlands), N. Dulvy (CEFAS, UK), E. E. Nielsen (DIFRES, Denmark), D. Bekkevold (DIFRES, Denmark), M. Heino (IMR, Norway), P. Lorance (IFREMER, France), H. Ojaveer, (Univ. Tartu, Estonia)

Biodiversity is the variation in the genetics and life forms of populations, species, communities and ecosystems. Biodiversity affects the capacity of living systems to respond to changes in the environment, and is essential for providing goods and services from ecosystems (e. g., nutrient cycling, clean water^{1,2}). As well as having intrinsic value, biodiversity has aesthetic value: many of us have admired the wonderful colours and shapes of fishes on coral reefs and in other coastal habitats. Some benefits of biodiversity are not apparent today but may be unlocked in the future (known as the option value): compounds derived from marine animals and plants may serve as medicine to prevent and cure more of our ills in the future. Biodiversity also has cultural value when it is directly linked to the cultural fabric of human societies.

Moreover, biodiversity is important for the future sustainability of marine natural resources that include commercial fisheries. Fisheries that exploit a range of species may have more stable catches than fisheries that exploit a single species³. A high genetic diversity within a fish population may protect it against environmental stressors (e. g., climate change, pollutants) and the spread of diseases.

According to the WSSD⁴ and other international agreements, countries have to manage their natural resources in ways which conserve both the resource and biodiversity (e. g., Biodiversity Action Plans for the Conservation of Natural Resources, Agriculture and Fisheries⁴⁻⁶). Here we summarize risks to the biodiversity of fish in European seas and recommend ways how existing fish diversity can be conserved, restored and managed.

Threats to fish biodiversity

The main factor that threatens marine fish biodiversity globally is fishing^{7,8}. For example, worldwide over 40 local populations of fish species have gone extinct as a result of overexploitation⁷. These local losses represent an erosion of global biodiversity. Moreover, stresses due to other factors such as climate change, habitat loss, invasive species, eutrophication and pollution can accentuate fishing-induced declines and inhibit or prevent recoveries⁸. For example, cod populations in the Baltic and North Seas both declined while fishing mortality rates were high and deteriorating climate and oceanographic conditions reduced the survival of young cod^{9,10}. Now that both populations are at very low levels, these environmental conditions (together with continued fishing at lower rates) are inhibiting recovery⁹⁻¹¹.

The long-term viability of many targeted and non-targeted species in EU waters is unknown because population assessments and surveys are not conducted; this situation applies for example to large parts of the Mediterranean and deepwater species that are among the most susceptible to

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² Contact: JG Hiddink. J.Hiddink@bangor.ac.uk, School of Ocean Sciences, University of Wales, Bangor, UK

overexploitation^{12,13}. Many other species, such as bluefin tuna^{14,15}, are exploited in ways which place the long-term sustainability of the populations and species at risk (e. g., catches not reported, both immature and adult fish are legally caught; fish below legal size are captured and landed). Lastly, there are many fish species which are not (or are no longer) targeted but nevertheless are caught as bycatch in sufficient quantities that they are vulnerable to local or more wide-spread extinction.

Detecting biodiversity change and its ecosystem consequences

Biodiversity includes scales of biological organisation from the genetic diversity within species to the variation in species richness within entire ecosystems. Traditionally, fish biologists have focused on studying species level biodiversity in fishery surveys. However, genetic tools are revealing more and more of the previously hidden biodiversity at lower organisational levels^{16,17}. Some genetically distinct populations may be adapted to local conditions and have specific behaviours and life histories (e.g., migration). Application of modern genetic technologies will in the future enable better predictions of how biodiversity of marine fishes responds to fishing and changes in the environment. Detecting such changes will require ongoing support for standardized and long-term research surveys of fish communities, and the taxonomic and genetic basis for correct species identifications. Standardized research surveys, when combined with historical fisheries information (e. g., from written archives or archaeological studies^{18,19}), provide baselines against which future changes in species richness and species/size composition can be detected, and causative factors identified. The effects of changes in biodiversity on ecosystem functioning are becoming evident: although there is uncertainty, many fishery-induced changes in species and size composition of fish communities are now well documented⁸. What has recently become clearer is that these changes affect the structure and functioning of marine ecosystems, including the biomass of species at lower trophic levels²⁰. Fisheries managers and policy makers must therefore take a precautionary approach in their management of fish diversity.

What the EU and its citizens can do to promote conservation and recovery of fish biodiversity

The EU has made substantial progress in recent decades in developing the legislative framework for conservation and recovery of fish biodiversity: the European Parliament and Council have passed several regulations designed to protect fish stocks, conserve fish biodiversity, and move towards an ecosystem-based approach to fisheries management. The EU is also committed to many international fishery and biodiversity agreements²¹. Despite the legislative progress, 22-53% of the exploited fish populations in north-east Atlantic waters have fallen below safe biological limits¹³ and many of these continue to be exploited at levels that hamper recovery; moreover some of the populations for which recovery plans have been developed and implemented have not recovered, partly because of high by-catches in fisheries targeting other species (e. g., North Sea cod).

These observations suggest that some of the well-intentioned legislation does not work in practice, or is not being fully implemented and enforced by political and national authorities. To solve this problem, we encourage the EU to expand its management options by including a broader range of conservation measures based on improved scientific knowledge and process understanding (e. g., more and larger MPAs where and when appropriate, improved effort control, restoration of habitats) and the member states of the EU to increase the transparency of their actions to stakeholders. We also encourage the EU and member states to support the conservation measures by ensuring *effective, prompt implementation and enforcement. This action alone would probably have greatest positive impact on fish biodiversity.* In this context we urge both the EU and its member states to give higher priority to conservation actions rather than short-term political and economic interests when negotiating quotas and recovery plans. Such an approach should also apply to the activities of EU fleets in waters other than those under EU control. These waters

include for example the high seas of the Atlantic, the Baltic, North, Adriatic, Mediterranean, and Black Seas.

There are also roles for fish consumers in the EU to support fish biodiversity. For example, consumers, including individuals, organisations, companies and fish processors can purchase fish which are caught in a sustainable way. Identifying such fish at the local fish shop would become easier if a sustainable fishery certification mechanism were developed and became available in all European countries. Such an approach however necessitates traceability for which appropriate genetic tools are required. Consumers can also support politicians who promote biodiversity-friendly legislation.

If actions such as those proposed here are implemented more widely and robustly, we will be able to reduce the loss of fish biodiversity and improve the chances that our ecosystems will continue to provide the goods and services that many of us now take for granted. If not, then our future images of diverse fish faunas may have to be extracted from archives rather than a leisurely snorkelling tour or a visit to a local fishmonger.

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