Fish indicators of coastal ecological resilience

Is fish diversity a useful indicator of the ecological resilience of the coastal zone? This is a first attempt to assess the characteristics of fishes that help to build resilience at the ecosystem level.

By Jorge Brenner

OVER THE PAST DECADE SEVERAL legal and scientific motivations have emerged that have led to better understanding of the coastal marine environment at the European level. As a result, there is a new structure in place for the study of marine biodiversity and ecological functioning. The present work integrates some of the conceptual approaches developed by the most relevant initiatives: BIOMARE (www.biomareweb.org), Census of Marine Life (www.coml.org) and MarBEF (www.marbef.org). Our research focuses on the development of an ecological framework for assessing the resilience of the coastal marine ecosystem in Catalonia, Spain.

The Catalonian coast is one of the fastest-developing areas in the Western Mediterranean, with more than 40% of its population (2.8 million) living in coastal municipalities. Coastal activities such as recreation and urbanisation demand large areas, with these two in particular being considered the major sources of pressure along the coast. This region is now preparing for the implementation of an Integrated Coastal Zone Management (ICZM) strategy, which has heightened interest in assessing the environmental services that the coastal zone provides to the global socio-economic system. This need for assessment has put scientists to work on understanding the properties that provide stability to the ecological systems, and thus goods and services to the society.

One of the properties of the stability of a system that we are analysing along the coast is ecological resilience. Resilience is a measure of the amount of energy required to move the ecosystem from one organised state of structure to another organised state (Holling, 1973) and has been long used in its inverse form: vulnerability. Carpenter *et al* (2001), Peterson *et al* (1998) and others suggest that resilience represents, in an integral manner, the condition of the entire system, whereas structure and other functioning indicators (individually) represent only one part of it.

LINK	- Swimming mode - Max weight - Total length - Depth range - Environment
MEMORY	- Reproduction type * - Growth * - Swimming mode - Feeding habit - Total length
RESPONSE	- Reproduction type * - Growth * - Feeding habit - Depth range

* Group of parameters

Fig 1. Fish attributes that will be used to form clusters.

There is substantial evidence in the literature that species diversity enhances ecosystem functioning (see a revision in Loreau *et al*, 2002). Fish provide several important functions that are thought to be relevant for system resilience and thus contribute to ecosystem stability (Holmlund and Hammer, 1999). This project will evaluate the contribution of fish to potential ecological resilience, specifically using their diversity in link, memory and response functions, from a macroecological perspective (ICSU, 2002; Lundberg and Moberg, 2003). The characteristics selected for analysis have been chosen on the basis of their role in the ecosystem's ability to reorganise following disturbance. The specific attributes of fish that will be used to form clusters or functional groups are shown in Figure 1.

A GIS has been implemented to develop a biophysical model of the natural communities and fish occurrences along the more than 800km of Catalonian coast. In the analysis, we will calculate the resilience based on the contribution of functional groups within each community. A conceptual model will also use the input of additional spatial sub-models that have been developed to study their interaction with individual communities' resilience (Figure 2).

Ecological resilience has three basic properties:

- the amount of change that the system can support before it moves from its stable domain
- the organisational degree of the system's components based on its structure and process
- the learning process of the system to adapt to new conditions (and survive).

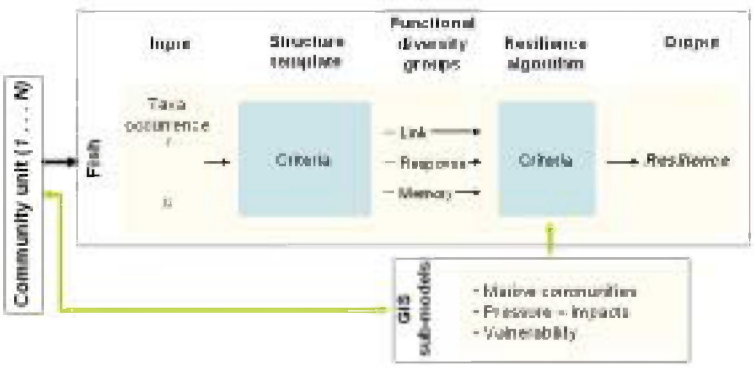

Fig 2. Conceptual model.

These will be used to analyse how ecological resilience relates to the ecological condition of the coast, and thereby construct an indicator (adapted from Carpenter *et al*, 2001).

The total resilience of the system will be assessed based on the individual values of the communities, through the condition indicator. In most areas, fish are a well-known biodiversity group and thus it is expected that the resulting spatial indicators and framework could be used to promote more sustainable coastal strategies and actions at a global scale. ●

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Completion of Cost-Impact

By Chris Emblow

COST-IMPACT (COSTING THE impact of demersal fishing on marine ecosystem processes and biodiversity), a Fifth Framework R&D project lead by Melanie Austen from Plymouth Marine Laboratory, was completed at the end of November 2004.

Sampling at sea.

Involving eleven partner institutes in six European countries, Cost-Impact aimed to address potentially conflicting objectives of maintaining sustainable fisheries in European waters while avoiding negative effects on the environment and conserving marine biodiversity.

Specifically, the project set out to provide advice to decision-makers on the impacts of demersal fishing on marine benthic biodiversity and its associated goods and services; how these impacts influence other marine ecosystems processes; and how likely values of goods and services provided by the marine environment are affected by fishing. This balance between science, socio-economics and policy was achieved through a series of well-balanced work packages.

Cost-Impact had three main scientific components:-

- Experimental field and mesocosm studies in Crete, Norway and Poland, examining sediment, water chemistry and macro- and meiofaunal biodiversity;
- Ecosystem modelling of the effects of fishing;
- Environmental economics modelling.

In addition, effort was focused on dissemination and communication of the project aims and results through a reference user group, which was established early on in the project. Through this group, representatives from the fishing and aquaculture industries, environmental managers and policy makers provided external input into the project direction and communication.

Field experimental studies carried out under Cost-Impact brought to light the complexity of the relationship between demersal fishing effects and changes in biodiversity and environment. In all studies there was a high degree of variability in the impacts of fishing, depending on sediment type, seasonality, trawling effort and biodiversity present. The mesocosm studies showed that removal of large bioturbating taxa through trawling may have important long-term effects on the ecosystem, which may prove to be more important than short-term direct effects such as habitat disturbance. Interactions between bioturbators, biodiversity and organic enrichment highlighted the need to take a holistic approach to managing anthropogenic impacts on the environment. Mesocosm nutrient experiments showed that the effect and role of bioturbating taxa in nutrient cycling patterns was important, and that some significant and complex patterns could be attributed to trawling effects.

In September 2004, the final workshop of the Cost-Impact project was held in Dublin, Ireland. The workshop was the culmination of three years' collaboration between fisheries scientists, benthic ecologists, ecosystem modellers, socio-economists, data managers and marine environmental policy and decision makers. Cost-Impact has been a commendable example of early user involvement through establishing a reference user group, and of the importance of integrating the natural sciences with the socio-economic. The final project report will be available on the project website shortly at www.cost-impact.org, which also gives further details of the Cost-Impact project. ●

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