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Categories of importance as a promising approach to valuate and conserve ecosystem integrity: the case study of Asilah sandy beach (Morocco)

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INTRODUCTION

The natural constraints and the impacts of human activities on marine, coastal and transitional ecosystems represent potential and permanent threats, which in turn may have a negative influence on the structure and functioning of these ecosystems, affecting species and leading to their regression or disappearance. This could negatively affect the maintenance of the biodiversity and particularly the sustainability of communities. The growing understanding and knowledge of these effects has lead to the development of management actions beyond the management of single species towards a consideration of the ecosystem as a whole. Actually, there is often greater interest in conserving ecosystem integrity than focussing on individual species (Roff & Evans 2002). To apply a management scheme, it is necessary to focus on those species and habitats that are major ecosystem components (phytoplankton, zooplankton, seabirds, fishes, marine mammals, benthos), and drivers of ecosystem structure and functioning. The need to establish conservation measures and protective legislation instruments is a crucial step after ranking the species according to their importance and interest for ecosystem health, quality and integrity (Roff & Evans 2002). For this reason, an evaluation of the categories of importance of each species or family becomes an essential and a promising management measure. In this study, we focused on the macrozoo-benthos of Asilah sandy beach located on the Atlantic coast in north-western Morocco and applied this conservation and valuation approach in real case (Figure 1). This approach should be a relevant input for Morocco, which is actually developing a conservation strategy and legislation for its natural areas.

SELECTION OF KEY SPECIES (FAMILIES) AND HABITATS

The sandy shore of Asilah (35º31'8.28" N and 06°00'43.2" W) is an extended (>3000 m length) and a wide beach (>100 m width) characterised by fine sand not colonised by vegetation. In the present study, we applied the tentative approach of ranking for categories of importance to the macrozoobenthos, in which we identified key species.

First, the species list found in the Asilah beach ecosystem was reduced by aggregating the species sampled (22 taxa) to families (obtaining 16 families). The biology, ecology and function of species at this taxonomic resolution were considered sufficiently similar to justify such an aggregation. Other studies argued that the loss of information caused by aggregation to a coarser taxonomic level than species or genus is generally negligible (Karakassis & Hatziyanni 2000). The second step of the analysis involved removing those families that are uncommon, little known, or clearly not important for the ecosystem. This reduced the number of families under consideration to eight. The third step involved collating for each family available data on distribution, life history characteristics, mortalities, densities and substrate preference, which formed the basis for the further evaluation of their importance for ecosystem's functioning.

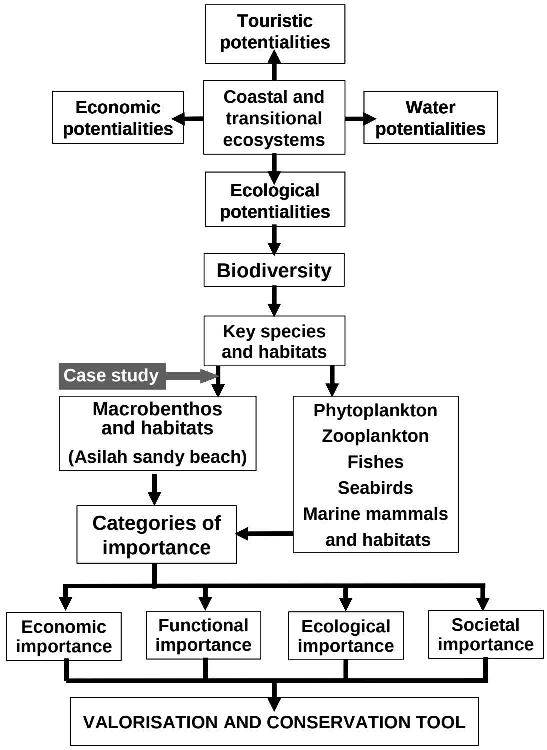

Figure 1: Relationships among ecological potential and categories of importance, including key species and habitats of coastal and transitional ecosystems.

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CATEGORIES OF IMPORTANCE

The goal of this approach was to identify those species or habitats that are important, either to humans (species harvested, habitats of interest for the tourism industry, habitat or species of conservation value) or because they are essential for ecosystem health and integrity. Four categories of importance were developed to select key species and habitats.

• ***Economic importance***. This category includes those species and habitats that have a monetary value. Many species of marine fauna are harvested and provide employment and/or profit to humans.

• ***Ecological importance***. This involved the evaluation of the importance of species and habitats in predator-prey relationships (a key role in the trophic web of ecosystems). In this category, we considered also the role played by the species as indicator of the ecological quality of their inhabited area. The ecological rank of each species was given according to AMBI software downloaded from AZTI's web site (www.azti.es).

• ***Functional importance***. Species and habitats provide important functions to the ecosystem (physico-chemical services to the ecosystem). The functional importance of species/families and habitats was determined using two sub-criteria: the importance of a species/family for the modification of (1) the biogeochemical environment ('biogeochemical functions') and/or (2) the physical and biological environment ('biological activity and habitat functions'). The first category refers to taxa that influence the nutrient dynamics, such as enhancing the flux of nutrients as a result of bioturbation, or improving water quality by filtering out toxins (Gabet *et al*. 2003). The second category refers to taxa that modify the physical and/or biological environment (Sandnes *et al*. 2000). This includes habitat forming taxa, i.e., they increase habitat complexity and provide refuges, or destabilise sediments through bioturbation (Biles *et al*. 2002). Habitats and taxa were categorised depending on whether they enhanced or decreased species diversity, richness and abundances of associated fauna. Finally, organisms were categorised that influence the associated fauna through disturbance or other interactions, either positive or negative. Examples of these interactions include the impacts of bioturbation on other organisms, or the competition for space among habitat forming species (Ciarelli *et al*. 1999).

• ***Societal importance***. This category includes species and habitats of conservation importance and value, which are considered important by the human society. Some of these species are protected by national or/and international legislation.

The four categories listed above were applied to the main components of the ecosystems: phytoplankton, zooplankton, seabirds, fishes, marine mammals and habitats in order to manage the whole ecosystem and conserve ecosystem integrity (Figure 1).

The present work was carried out based on data resulting from the seasonal sampling of macroinfauna on Asilah sandy beach performed from June 2006 to June 2007. We discuss here the eight dominant families (abundances ≥500 individuals) according to the four categories.

MACROZOOBENTHIC KEY SPECIES/FAMILIES OF ASILAH SANDY BEACH

A. ARTHROPODA - CRUSTACEA

1. Amphipoda Haustoreidae: *Haustorius arenarius* and *Urothoe grimaldii*

Economic importance. None.
Ecological importance as prey. They represent the diet of common gobies, carrelets (Pasquaud *et al*. 2004) and flounders and some megafauna species, particularly crabs. They are probably preyed upon by all wader species that forage on intertidal sandy shores.
Ecological importance as predator: They are not predators. The species of this family are considered to be surface-deposit feeders and suspension feeders (Lincoln 1979).
Ecological importance as bioindicator: *H. arenarius* and *U. grimaldii* are sensitive species to organic matter enrichment.
Functional importance. *Biogeochemical functions* and *biological activity and habitat functions*: None.
Societal importance. None.

2. Amphipoda Pontoporeiidae: *Bathyporeia pilosa* and *B. pelagica*

Economic importance. None.
Ecological importance as prey. These species are preyed upon by gobies (Pasquaud *et al*. 2004) and some waders.
Ecological importance as predator. None. This family is mainly composed by surface-deposit feeding species (Lincoln 1979).
Ecological importance as bioindicator: *Bathyporeia* spp. are sensitive species to organic matter enrichment.
Functional importance. No information found.
Societal importance: None.

3. Amphipoda Oedicerotidae: *Pontocrates arenarius*

Economic importance: None.
Ecological importance as prey. This family represents an important food resource for portunid crabs and many fish species. These amphipods constitute very important prey items for a large number of fish, seabird and invertebrate predators.
Ecological importance as predator. Species belonging to this family are known as surface-deposit feeders and suspension feeders (Lincoln 1979); none is predatory.
Ecological importance as bioindicator: *P. arenarius* is an indifferent species to organic matter enrichment.
Functional importance. No information found.
Societal importance. None.

4. Isopoda Cirolanidae: *Eurydice affinis* and *E. pulchra*

Economic importance. None.
Ecological importance as prey. They are mainly eaten by crabs, fish and seabird predators especially waders feeding in the saturation zone.

Ecological importance as predator. Species of this family are generally considered to be carnivores and they can prey on larvae, meiofauna and some small sized amphipods.
Ecological importance as bioindicator: *Eurydice* spp. are classified as sensitive species to organic matter enrichment.
Functional importance. No information found.
Societal importance. None.

5. Decapoda Portunidae: *Portumnus latipes*

Economic importance. Specimens of this species are sometimes used as fish bait, together with other pagurid crabs (Fowler 1999).
Ecological importance as prey. Portunids were reported in the diet of wolfish *Anarhichas lupus* (Liao & Lucas 2000).
Ecological importance as predator. *P. latipes* is an omnivore species feeding on crustaceans and polychaetes inhabiting sandy beaches. Macroalgae are also consumed as accessory food in its diet (Chartosia *et al.* 2010). *P. latipes* was also considered as the most active foot nipper of *Donax* spp. on sandy beaches (Salas *et al*. 2001).
Ecological importance as bioindicator: *P. latipes* is considered as a sensitive species to organic matter enrichment.
Functional importance. *Biogeochemical functions*: The Portunid *Carcinus maenas* is known to accumulate PCB and heavy metals such as mercury and cadmium (e.g. Bondgaard *et al.* 2000). *Biological activity and habitat functions*: Portunids are of high ecological importance as scavengers and predators. Crabs are, in general, bioturbation agents that lead to incorporation processes of terrestrial sediment into marine sediment (Cummings & Thrush 2004).
Societal importance: None.

B. MOLLUSCA - BIVALVIA

1. Donacidae: *Donax trunculus*

Economic importance. Donacids species are sometimes used as fish bait together with crabs (Fowler 1999). In many countries, these molluscs, like other bivalves are collected by hand or mechanically using tractor dredges or suction dredges for the commercial market.
Ecological importance as prey. Donacids are preyed upon by waders such as oystercatchers, knots, dunlins and grey plovers (Goss Custard *et al*. 1977). On the Moroccan coast, *Donax venustus* is preyed on sandy shores by the Yellow-legged Gull *Larus michahellis*. Various invertebrate predators, such as the crab *Carcinus maenas*, feed on donacids and cockles. However, the predation by juvenile *C. maenas* can have large impacts on the bivalve spat biomass (Jensen & Jensen 1985).
Ecological importance as predator. No predation activity exists for this species because of its feeding regime (suspension feeder).
Ecological importance as bioindicator. *D. trunculus* is known as a sensitive species to organic matter enrichment.
Functional importance. *Biogeochemical functions*: This species is known to accumulate heavy metals. It can be found in high densities and may therefore filter out large quantities of plankton.
Biological activity and habitat functions: It may compete for space with other infaunal bivalves. *D. trunculus* may affect sediment turnover and nutrient recycling, as large burrowing bivalves.
Societal importance. None.

C. ANNELIDA - POLYCHAETA

1. Spionidae: *Scolelepis squamata* and *S. mesnili*

Economic importance. None.
Ecological importance as prey. The major predators on these species are wading birds, eider ducks, crabs, fishes (Speybroeck *et al*. 2007) and also some carnivore polychaetes (*Nephtys* spp. and *Eteone longa*).
Ecological importance as predator. Not predatory species. *S. squamata* is reported to be a deposit feeder, but it can change its feeding behaviour to suspensivore feeder when water flow occurs (Bayed *et al*. 2006).
Ecological importance as bioindicator: *S. squamata* and *S. mesnili* are tolerant species to excessive organic matter enrichment.
Functional importance. Biogeochemical functions: *S. squamata* has been regarded as a suitable biomonitor for heavy trace metals (bioaccumulation agents), along with other polychaete species. *Biological activity and habitat functions*: This species is able to build galleries in the sediment, thereby promoting its oxygenation, which in turn probably facilitates increase in abundance of burrowing invertebrates.
Societal importance. None.

2. Nephtyidae: *Nephtys cirrosa*

Economic importance. The largest specimens of *Nephtys* are used as bait and are particularly sought-after by anglers, including match fishermen. Some are used as food resource in aquaculture (Fowler 1999).
Ecological importance as prey. The large size nephtids are frequently eaten by bird predators (particularly eiders and waders).
Ecological importance as predators. Nephtids are generally considered carnivores (Fauchald & Jumars 1979) and they have predation impacts on macrofauna densities (e.g. Schubert & Reise 1986).
Ecological importance as bioindicator: *N. cirrosa* is an indifferent species to organic matter pollution.
Functional importance. *Biogeochemical functions*: Nephtids were recorded to accumulate polychlorinated biphenyls (Means & McElroy 1997). *N. cirrosa* has been reported as suitable bioaccumulation agent of heavy trace metals. *Biological activity and habitat functions*: No information found.
Societal importance. None.

CONCLUSION

The use of the categories of importance for sandy beach macroinfauna should provide managers, scientific community and policy makers with a useful and a pertinent tool for valuating and conserving sandy beach ecosystems and may be used for other ecosystems. This kind of tool also helps to assign a key status to macrozoobenthos similar to that ascribed to the megafauna (fishes, birds, reptiles and marine mammals), which is highly considered in protection and planning processes and is taken into account in national decisions and international agreements and conventions aiming at the conservation and protection of fauna and habitats.

Moreover, the use of the categories of importance may encourage users, NGOs and other stakeholders to focus on a wider range of sandy beaches and pay special attention to them, when developing integrated conservation strategies and sustainable management plans that would be adequate to their ecological importance.

In the case of Asilah beach, none of the species of the macrozoobenthos are currently protected by any conservation directives or legislation. The valuable biodiversity of this coastal ecosystem is not covered by any conservation initiatives and actions. As a matter of fact, a societal motivation appears a necessary measure to ensure its protection and management through a scientifically sound valuation.

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References

Bayed A., Cherkaoui E. & Glémarec M., 2006. Population dynamics of *Scolelepis Squamata* (Annelida: Polychaeta) from a Northwest African beach. *Cah. Biol. Mar.*, 47(2), 143-155.

Biles C.L., Paterson D.M., Ford R.B., Solan M. & Raffaelli D.G., 2002. Bioturbation, ecosystem functioning and community structure. *Hydrol. Earth System Sci.*, 6(6), 999-1005.

Bondgaard M., Noerum U. & Bjerregaard P., 2000. Cadmium accumulation in the female shore crab *Carcinus maenas* during the moult cycle and ovarian maturation. *Mar. Biol.,* 137, 995-1004.

Chartosia I., Kitsos M. & Koukouras A., 2010. Seasonal Diet of *Portumnus Latipes* (Pennant, 1777) (Decapoda, Portunidae). *Crustaceana*, 83(9), 1901-1913.

Ciarelli S., Van Straalen N.M., Klap V. A. & Van Wezel A.P., 1999. Effects of sediment bioturbation by the estuarine amphipod Corophium volutator on fluoranthene resuspension and transfer into the mussel (*Mytilus edulis*). *Environ. Toxicol. Chem*., 18: 318-328.

Cummings V.J. & Thrush S.F., 2004. Behavioural response of juvenile bivalves to terrestrial sediment deposits: implications for post-disturbance recolonisation, *Mar. Ecol. Progress Series*, 278, 179-191.

Fauchald K. & Jumars P.A., 1979. The diet of worms: a study of polychaete feeding guilds. *Oceanogr. Mar. Biol. Annual Review,* 17, 193-284.

Fowler S. L., 1999. *Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites*. English Nature (UK Marine SACs Project), 132 pp.

Gabet E.J., Reichman O.J. & Seabloom E.W., 2003. The effects of bioturbation on soil processes and sediment transport. *Annu. Rev. Earth Planet. Sci*., 31, 249-273.

Goss-Custard J.D., Jones R.E. & Newbery P.E., 1977. The ecology of the Wash. I. Distribution and diet of wading birds (Charadrii). *J. Applied Ecol.,* 14, 681-700.

Jensen K.T. & Jensen J.N., 1985. The importance of some epibenthic predators on the density of juvenile benthic macrofauna in the Danish Wadden Sea. *J. Exp. Mar. Biol. Ecol.,* 89, 157-174.

Karakassis I. & Hatziyanni E., 2000. Benthic disturbance due to fish farming analyzed under different levels of taxonomic resolution. *Mar. Ecol. Progress Series* 203, 247–253.

Leopold M.F., 2002. Eiders Somateria mollissima scavenging behind a lugworm boat. *J. Sea Research*, 47(1), 75-82.

Liao Y.Y. & Lucas M.C., 2000. Diet of the common wolfish *Anarhichas lupus* in the North Sea. *J. Mar. Biol. Ass. UK,* 80, 181–182.

Lincoln R.J., 1979. *British Marine Amphipoda: Gammaridea*. British Museum (Natural History), 818, 657 p.

Matisoff G., Fisher J.B. & Matis S., 1985. Effects of benthic macroinvertebrates on the exchange of solutes between sediments and freshwater. *Hydrobiologia*, 122, 19-33.

Means J.C. & McElroy A.E., 1997. Bioaccumulation of tetrachlorobiphenyl and hexachlorobiphenyl congeners by *Yoldia limatula* and *Nephtys incisa* from bedded sediments: Effects of sediment- and animal-related parameters. *Environ. Toxicol. Chem.,* 16, 1277-1286.

Pasquaud S., Girardin M. & Elie P., 2004. Etude du régime alimentaire des gobies du genre *Pomatoschistus* (*P. microps* et *P. minutus*) dans l'estuaire de la Gironde (France). *Cybium*, Rev. Internat. Ichtyol., 28(1), suppl. RIF 2003, 30 avril 2004.

Roff J.C., & Evans S.M.J., 2002. Frameworks for marine conservation - non-hierarchical approaches and distinctive habitats. *Aquatic Conserv. Mar. Freshwater Ecosystems,* 12(6), 635-648.

Salas C., Tirado C. & Manjón-Cabeza M.E., 2001. Sublethal foot-predation on Donacidae (Mollusca: Bivalvia). *J. Sea Res.,* 46(1), 43-56.

Sandnes J., Forbes T., Hansen R., Sandnes B. & Rygg B., 2000. Bioturbation and irrigation in natural sediments, described by animal-community parameters. *Mar. Ecol. Prog. Ser.,* 197, 169-179.

Schubert A. & Reise K., 1986. Predatory effects of *Nephtys hombergii* on other polychaetes in tidal flat sediments. *Mar. Ecol. Progress Series*, 34(1–2), 117-124.

Speybroeck J., Alsteens L., Vincx M. & Degraer S., 2007. Understanding the life of a sandy beach polychaete of functional importance - *Scolelepis squamata* (Polychaeta: Spionidae) on Belgian sandy beaches (northeastern Atlantic, North Sea). *Estuar. Coastal Shelf Sci.,* 74, 109-118.