**MarBEF Theme 3: The Socio-economics of Marine Biodiversity**

# Exchange rate between scientific currencies
## – an application to the marine environment

By Tomaz Dentinho, Samanta Vizinho, Vasco Silva, Fernando Tempera, Frederico Cardigos    Ricardo Santos

EACH SCIENTIFIC PARADIGM has its own valuation system. Ecologists design maps with environmental values assuming their relevance for the sustainability of the ecosystem. Socio-cultural scientists value things according to their role in society along space and time. Economists prefer cost-benefit analysis where everything can be translated into money (Nunes *et al*, 2001; de Groot *et al*, 2002; Farber *et al*, 2002; Limburg *et al*, 2002). The question is, how to combine different disciplinary perspectives in a consistent decision support methodology?

The objective of the methodology presented in this article is to give an answer to this question. It is assumed that the economic, ecological and cultural valuations complement rather than substitute each other. It is also supposed that each one of these valuations can be allocated to some spatial referential or map. Finally, it is believed that public decisions should be consistent so that trade-offs between similar values must be the same along all decisions. Based on that, the idea of an exchange rate between disciplinary valuations is explained and applied for the Faial-Pico Channel.

## Methodology

In every point of a regulation boundary (f) that limits alternative uses of the environment, the total value for one use (Vfa) must be exactly the same as the total value for a different use (Vfb).

**1.** Vfa = Vfb

On the other hand, each total value (Vfa, Vfb) results from adding together the economic values (Vfea,Vfeb), the ecological values (Vfba,Vfbb) and the socio-cultural values (Vfca,Vfcb), each one of them multiplied by an Exchange Rate Function. The Exchange Rate Function (ρ) relates the economic values to the ecological values. The Exchange Rate Function (σ) relates the economic values to the socio-cultural values.

**2.** Vfa = Vfea + Vfba x ρ + Vfca x σ

**3.** Vfb = Vfeb + Vfbb x ρ + Vfcb x σ

In the boundary (f), the value associated with alternative uses (a,b) are equal. Therefore:

**4.** (Vfea-Vfeb) = (Vfbb-Vfba) x ρ + (Vfcb-Vfca) x σ

Notice that the boundary line has many points. Assuming that it is possible to obtain the economic, socio-cultural and ecological values for different alternatives (a,b…), then it is also possible to estimate the functions (ρ) and (σ). If these functions are just simple parameters, then they can be considered as "exchange rates between disciplinary valuations": between economists and ecologists (ρ), between economists and historians (σ), and also between ecologists and historians (σ/ρ). Note that if there is no difference between socio-cultural values for alternative uses then (Vfca-Vfcb) = 0 and:

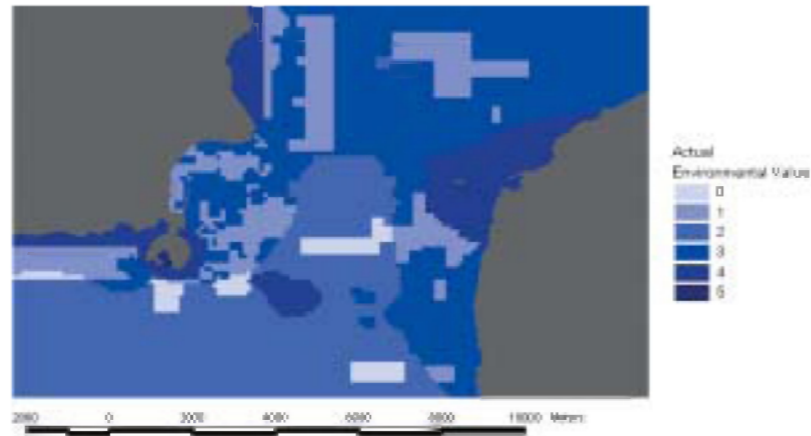**5.** ρ = (Vfea – Vfeb) / (Vfbb-Vfba)



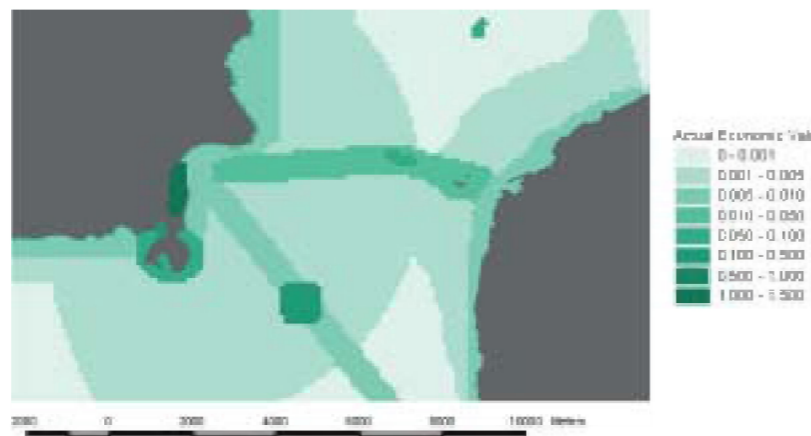**Fig 1.** Environmental values for the actual use in Faial-Pico Channel.



**Fig 2.** Economic values for the actual use in Faial-Pico Channel.

## Application to Faial-Pico Channel, Azores

The application of an exchange rate between disciplinary valuations for the Faial-Pico Channel is based on a Geographical Information System (GIS). The study area was divided into square parcels of 100m x 100m. Each one of these small areas was valuated in environmental terms, based on the bottom type and the bathymetry and taking into account their relevance for the ecosystem **(Figure 1)**. Shallow areas were given a higher value than deeper areas, as they concentrate higher biomass and biodiversity. Rocky bottoms were considered more valuable than soft bottoms, as they concentrate most of the conspicuous biodiversity and fishery resources. Areas designated for conservation and harvest refugia (namely under Natura 2000 sites and no-take areas for limpets) received a higher environmental value. This approach results in infra-littoral (<50m deep) rocky bottoms within designated areas being assigned the highest value.

On the other hand, depending on the activities allowed by regulatory measures, each one of these small areas has an associated economic value related to the employment supported by different activities: fisheries, tourism and harbour logistics **(Figure 2)**.
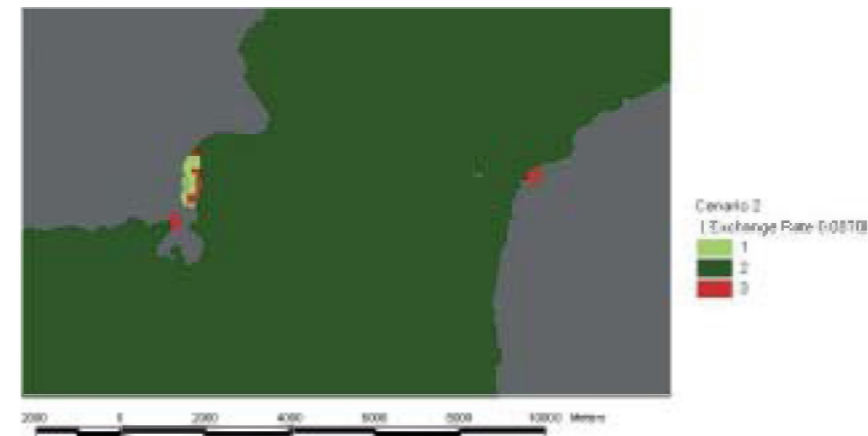


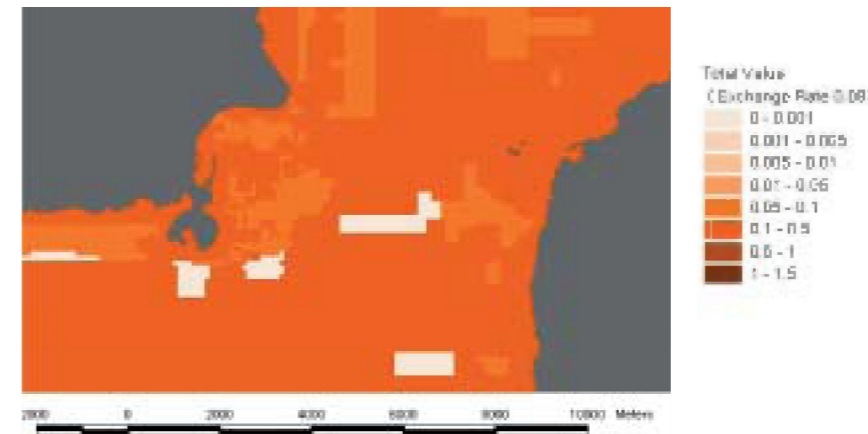**Fig 3.** Optimal regulation [ρ = 0.023; ρ = 0.053; ρ = 0.087].



**Fig 4.** Total sea use value [ρ = 0.087].

Regulatory boundaries are the result of discussions between experts, stakeholders and politicians. In each parcel belonging to these boundaries it can be expected that the environmental and economic value associated with inclusion inside the regulatory restriction is exactly the same as the value of being outside of that rule. Therefore, taking account of the uses of the sea allowed or forbidden in the different parcels of regulatory boundaries, and based on the environmental and economic values of being inside or outside of those limits, it is possible to have estimates for (ρ) in expression (5).

In the Faial-Pico Channel, there are only three regulatory boundaries from which it is possible to derive exchange rates between disciplinary valuations. Table 1 presents these cases, taking account of the values of being inside or outside of the regulatory boundary for the small areas where those boundaries are defined.

Having (ρ), it is then possible to generate various interesting outcomes. First, it is possible to obtain the best marine regulatory map **(Figure 3)**, by choosing, for each parcel, the rule that leads to the maximum Total Value among all the other regulatory alternatives (1 = maintain the rule; 2 = more conservationist rule; 3 = more intensive use rule). Looking at Figure 3, it is clear that, for all the estimated exchange rates (ρ = 0.023; ρ = 0.053; ρ = 0.087) the optimisation of regulation will lead to a consistent regulatory map that represents a more conservationist solution than the present one. In this conservationist scenario, all of the channel with the exception of Horta Port, Madalena Port and Porto Pim Bay would be a natural park [as previously proposed by Tempera *et al* (2001) and Tempera & Santos (2003)].

Second, it is possible to design the maps of Total Sea Use Values for each one of the exchange rates and their respective plans. When the exchange rate is [ρ = 0.087], the Total Value of the Channel is equivalent to 3770 employments **(Figure 4)**.

## Conclusion

The challenge was to combine the different disciplinary perspectives in a consistent decision support methodology. The results seem quite interesting. First, there is a method to monetarise non-monetary values. Second, this method is also suitable to value non-use values without the expensive adoption of the Contingency Valuation. Finally, the exchange rate between disciplines can also be used to assess the internal consistency of regulatory plans or to design different plans according to various exchange rates.

**Tomaz Dentinho**
MarBEF Theme 3
University of the Azores
Department of Agricultural Sciences
Email: tomaz.dentinho@angra.uac.pt

## Recommended reading

**De Groot, R, Wilson, M, Boumans, RMJ, 2002.** A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecol. Econ.* **41** (2002), 393-408.
**Farber, S, Costanza, R, Wilson, M, 2002.** Economic and ecological concepts of valuing ecosystem services. *Ecol. Econ.* **41**, 375-392.
**Limburg, KE, O'Neil, RV, Costanza, R, Farber, S, 2002.** Complex systems and valuation. *Ecol. Econ.* **41**, 409-420.
**Nunes, P, Van Den Bergh JCJM, 2001.** Economic valuation of biodiversity: sense or nonsense? *Ecol. Econ.* **39** (2001), 203-222.

**Table 1.** Exchange rates between ecological and economic values in regulatory boundaries of Faial-Pico Channel.

| | Economic Value | | | | | | Ecological Value | | Exchange Rate |
|---|---|---|---|---|---|---|---|---|---|
| | Fish In | Fish Out | Tour In | Tour Out | Total In | Total Out | In | Out | ρ = [Vfe(in) – Vfe(out)]/[Vfb(out)-Vfb(in)] |
| Regulation on limpets (50% of coastal area): | 0.0110 | 0.016 | 0.0340 | 0.0060 | 0.0450 | 0.0225 | 3 | 2 | ρ = 0.023 |
| Regulation that forbids tourism and fisheries in "Monte da Guia": | 0.000 | 0.030 | 0.000 | 0.057 | 0.000 | 0.087 | 5 | 3 | ρ = 0.087 |
| Regulation that forbids fisheries 50% of fisheries in "Baixa do Sul": | 0.1322 | 0.1983 | 0.0510 | 0.0382 | 0.1832 | 0.2366 | 4 | 3 | ρ = 0.053 |