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Analysis of the artisanal fisheries in the Atlantic Arc based on the DPSIR framework

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Analysis of the artisanal fisheries in the Atlantic Arc based on the DPSIR framework

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1. Introduction

To guarantee the sustainable development of artisanal fisheries, and thus ensuring the preservation of the exploited ecosystems, as well as the socio-economic stability of fishermen communities, management actions are required. This includes the specification of effective policies and decisions by managers, stakeholders or regulatory authorities. The decision-making process needs to be supported by updated information about the whole system under analysis. The collection and organization of the relevant data based on an appropriate set of indicators is seen as a good practice, simplifying, quantifying and qualitatively describing a system, consistently over time.

This paper applies the Driving force – Pressure – State – Impact – Response (DPSIR) framework (EEA, 1999), from which a set of indicators is defined. These indicators are further used to describe the artisanal fisheries in the Atlantic Arc, particularly the dredge fisheries in Portuguese south coast.

The paper is structured as follows. General DPSIR concepts are reviewed in section 2. In section 3 a reflection over the DPSIR applications in the fisheries context is made, and a set of general DPSIR indicators for monitoring artisanal fisheries in the Atlantic Arc is presented. The application of the selected DPSIR indicators to the study of the artisanal dredge fleet that operates in the south coast of Portugal is made in section 4. Finally, conclusions are discussed in section 5.

2. DPSIR framework overview

The Organization for Economic Co-operation and Development (OECD) developed the Pressure – State – Response (PSR) framework in 1993, where environmental status and human actions are described in terms of Pressure (P), State (S) and Response (R) indicators (OCDE, 1993). The PSR framework was enhanced by the European Environmental Agency (EEA) in 1999, becoming the Driving force – Pressure – State – Impact – Response (DPSIR) framework, illustrated in Figure 1 (EEA, 1999).

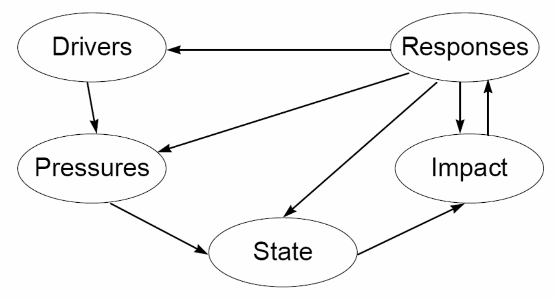

Figure 1. The DPSIR Framework (EEA, 1999).

Following the original guidelines of EEA (1999), all DPSIR indicators are descriptive and aim to directly measure some feature of the real world. Further the objective of the framework is to provide organized and complete data to main stakeholders so they can perform well sustained management decisions.

Driving forces indicators intend to describe social, demographic and economic developments in society, as it is stated in EEA (1999) report. This report also identifies "*the population growth and the developments in the needs and activities of individuals*" as primary driving forces. Different concepts of driving forces have been applied in literature, depending on the context and dimension of the study. In the Henriques et al. (2008) study, where the ecological status of a marine environment is measured with DPSIR, the suggested driving forces were economic activities such as Agriculture, Aquaculture, Fishing and Industry. A more detailed perspective is proposed in the EEA (2002) report, where market demand, technological improvement and need for water resources are pointed as possible driving forces to the aquaculture segment.

Pressures are the human actions that can induce environmental change. In the review of DPSIR definitions performed by Maxim et al. (2009), it is stated that pressure indicators are normally linked to the unwanted changes, normally those human actions with potential to cause damage and degradation. The EEA (1999) report illustrates CO2 emissions per sector and the amount of land used for roads as pressure indicators. In the Henriques et al. (2008) research, industrial effluents discharges was chosen as an industry pressure.

State indicators aim to illustrate the changes exploited ecosystem with chemical, physical and biological parameters. In the EEA (1999) report, atmospheric CO^2 concentrations, temperature and fish stocks are presented as examples. Depending on the focus of the study, the state can also belong to a social or economic dimension. The EEA (2002) report exemplifies consumption preferences as a state indicator to describe consumers and public opinion.

Impacts can be defined as the negative effects of human activities, perceived into the environment and society. The increase in temperature and the rise of sea level are two major examples pointed out in the EEA (1999) report. Impacts can also be related to social and economic dimensions. In the Pirrone et al. (2005) DPSIR application, with aim to reduce and control an eutrophication issue in a river, impact indicators are divided into two main groups: coast-ecology (e. g. habitat loss and concentration of nitrogen), and coast socio-economic (e. g. reduced tourism and problems to reach objectives of WFD).

Responses are all the measures performed by society with the aim to improve the system, directly on D, P, S or I categories. This can be achieved performing preventive, adaptive or curative actions. Lin et al. (2007) studied temporal changes in a coastal wetland, and some response indicators applied were the rational use of coastal wetland, the waste water treatment capacity and the natural conservation area.

3. Methodology: the DPSIR framework applied to artisanal fisheries

In order to apply the DPSIR framework to artisanal fisheries, it is further necessary to adapt the former concepts. Accordingly, the adopted viewpoints for each DPSIR category are described in the following paragraphs.

This study considers the driving forces as the social and economic motivations for the existence of fishing activity. A similar perspective was proposed in the EEA (2002) report, with fishing tradition, fishing capacity and market demands suggested as driving forces indicators for the fishing industry. The Mangi et al. (2007) research applied DPSIR framework to artisanal fisheries in Kenya, and the selected driving forces were also related to social and economic dimensions: unemployment, tradition, culture, tourism and poverty. The Ojeda-Martínez et al. (2009) study also described the fishing sector according to this perspective, selecting driving indicators such as GDP produced by the sector, per capita income in the area and number of fishers.

To describe the pressures of the fishing activity, aspects related with technical characteristics of vessels and with the intensity of performed fisheries are considered. The intensity is related with the time spent at sea, the covered area, the discards and the quantities of fish caught. In the Ojeda-Martínez et al. (2009) study, indicators such as fishing time, total biomass extracted and fishing ground were selected as fishing pressures.

Under the artisanal fisheries context, sea is the exploited ecosystem that can be characterized with biological, chemical and physical indicators. Biological indicators aim to describe the living species in the ecosystem, particularly the ones that are being caught. Mangi et al. (2007) selected fish abundance and sea urchin populations as state indicators. Ojeda-Martínez (2009) study also shares this viewpoint by selecting abundance, diversity and trophic categories as state indicators. Chemical and physical indicators are intended to measure environmental properties, such as nutrient concentrations and temperature.

The adopted definition of impacts considers social and economic negative effects only because the negative environmental changes are already included in the state indicators, and there is no need to repeat indicators in both categories. The EEA (2002) report suggests *changes in the economic results* and *change in fishing behaviour: effort, gear, zones* as impact indicators to describe fishing industry. The impacts suggested by Mangi et al. (2007), in the artisanal fisheries context, are declining in fish catch, livelihood benefits compromise and increased exclusion / conflicts.

Finally, response indicators are society actions which aim to improve the fishing activity, and these can include environmental, social and economic enhancement. This viewpoint is in agreement with other DPSIR applications in literature. Mangi et al. (2007) selected legislation, planning regulations, education and awareness as response indicators. The marine protected area and the budget for educational programs are two response indicators selected by Ojeda-Martínez et al. (2009).

Considering the concepts previously highlighted, a set of DPSIR indicators is proposed to describe the artisanal fisheries in the Atlantic Arc. This set is presented in Table 1, which details each indicator with its respective definition and units of measure. Indicators are organized into sub-indicators whenever this detail is considered relevant. Annual periodicity of measure for each indicator is assumed, since it is suitable to characterize artisanal fisheries.

Table 1. DPSIR indicators for artisanal fisheries.

	Indicator	Sub-indicator	Description	Units
Driving - Forces	Fishermen characterization	Number of fishermen	Number of fishermen	Number
		Social context of fishermen	Average monthly income in the household.	Euros
		Age of fishermen	Average of age of fishermen	Number
		The influence of fishing in the community	% of families with at least a person that works directly in the activity	Number
		Educational level of fishermen	Average educational level of fishermen	Years of schooling
	Demand of target species	Demand from local consumption	Demand from local consumption (including tourism)	Euros, tonnes
		Exports of target	Exports of target species	Euros,
	Supply of target species	Imports	Volume of imports of target species	tonnes
		Supply from aquaculture	Production from aquaculture	tonnes
		Supply from competing fleet	Captures from competing fleets	tonnes
	First Sell price		Average first sell price	Euros/kg
	Second Sell price		Average second sell price	Euros/kg
	Activity costs	Fuel costs	Average fuel price	Euros/m^3
		Capital investment	Total cost of capital investment	Euros
		Cost of human resources	Total cost of human resources	Euros
	Revenue from artisanal fisheries		Total revenue of the activity	Euros
			Time series with revenue of target species	Euros
Pressure	Fishing effort	Fishing trips	Total number of fishing trips	Number
		Fishing area	Area where the fisheries occur	Km^2
	Fishing power	Number of vessels	Number of vessels that exercised artisanal	Number
		Crew members	Average number of fishermen per vessel	Number
		Vessels power	Average power of the vessels	kW
		Vessels GRT	Average GRT of the vessels	tonnes
		Vessels age	Average age of the vessels	years
		Vessels length	Average length of the vessels	meters
		Vessels licenses	Average number of licenses	Number
	Declared catches		Quantity of declared catches	tonnes
	Non-complying with legislation		Estimation of the undeclared captures	tonnes
	Discards		Annual quantity of organic matter thrown to the sea	tonnes

	Indicator	Sub-indicator	Description	Units
State	Changes in target species abundance		Time series with the abundance of target species.	g (biomass) /m3
	Changes in water pH		Time series with the pH of the water	pH
	Changes in water temperature		Time series with the water temperature	ºC
	Change in primary production		Time series of primary production using ^{14}C incorporation	Rate of respiration
	Contamination		Time series with concentration of pollutants in water.	mg/l
	Tides		Average velocity of the tides	Km/h
	Mean size of target species		Time series with mean size of the target	mm
Impact	Catch per trip		Average quantity of captures performed per trip	kg
	Revenue per trip		Average revenue per trip	Euros
	Costs per trip		Average cost of a fishing trip	Euros
	Profitability of a trip		Average profitability achieved in a fishing	Euros
	Catches quality for human consumption		Number of diseases episodes associated with the consumption of the target species.	Number
Response	Enforcement and compliance		Number of monitoring activities by authorities.	Number
	Subsidies		Total amount of money given to fishermen as subsidies	Euros
	Educational programs	Number of programs	Number of available programs	Number
		Number of fishermen participating	Number of fishermen that attended courses / programs	Number
	Legislation	Limits of captures	Limits of captures for each target specie	kg / trip
		Interdiction periods	Number of days that artisanal fisheries where interdicted	Number
		Technical characteristics of fishing art	Technical characteristics that are regulated	Description

4. DPSIR application to dredge fisheries in the Portuguese south coast

Artisanal vessels dedicated to dredge fisheries can be classified into two fleet segments: local and coastal. Local fleet vessels have an overall length lower than 9 meters and the coastal fleet vessels have an overall length between 9 and 14 meters. Artisanal dredge fisheries are performed with dredges towed by boat to harvest bivalve mollusks, from the seabed. The four main bivalve species targeted in the south coast of Portugal are: surf clam (*Spisula solida*), donax clam (*Donax trunculus*), razor Clam (*Ensis siliqua*) and striped venus (*Chamelea gallina*). These species are illustrated in Figure 2.

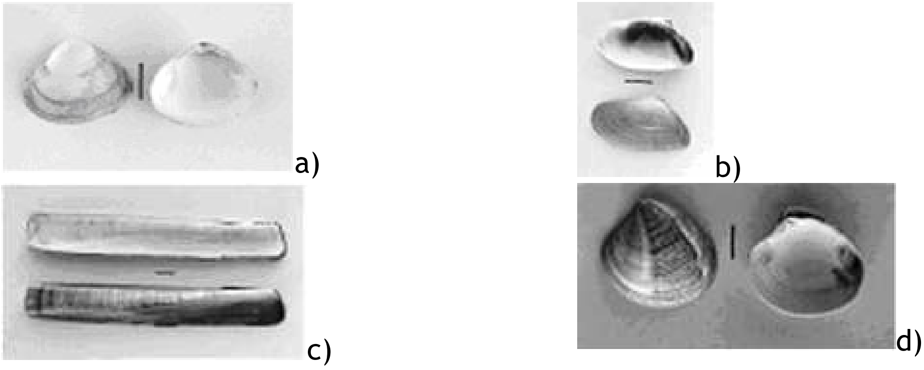

Figure 2. Target species of dredge fisheries in Algarve coast: surf clam (a), donax clam (b); razor clam (c) and striped venus (d). Scale bar = 1 cm.

Two types of dredges can be used in the fishery: the grid dredge (GD), where the catch is retained in a metallic grid, and the traditional dredge (TD), where the catch is retained in a net bag attached to the dredge mouth, as illustrated in Figure 3. The GD is the most recent dredge, wed after 1999. At the moment, the TD is only used for targeting razor clams, and the majority of the Portuguese south dredge fleet uses the grid dredge (Gaspar et al. 2003).

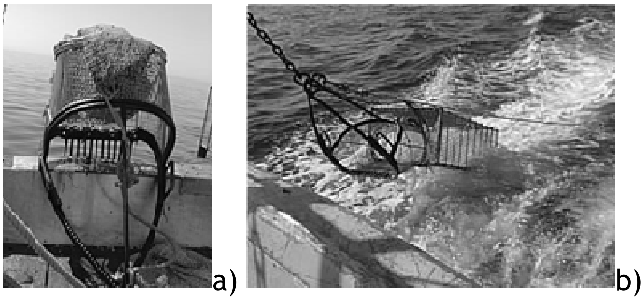

Figure 3. Applied dredges: traditional dredge (a) and grid dredge (b).

In this section the set of DPSIR indicators proposed above is applied to the dredge fisheries in the south coast of Portugal, as a case study. This is accomplished with the collection and analysis of data available for the entire fleet for each DPSIR category. The data used in this research was provided by the Portuguese General Directorate of Fisheries and Aquaculture (DGPA) and the National Laboratory of Marine Research (INRB-L/IPIMAR). However, it was not possible to obtain data for some indicators, due to the lack of historical records. This research can also contribute to suggest future data collection procedures.

4.1. Driving Forces

Fishermen characterization

For the fishermen characterization indicator, data is available only for the age and educational level of fishermen, and for the year of 2005. For this year, the average age of fishermen was 45 years old (considering both skippers and crew members). Regarding the educational level a likert scale was considered, where low level means some frequency of 1st cycle of basic school, medium level some frequency of 2nd or 3rd cycle of basic school, and high level the completion of the 3rd cycle of basic school. Within this classification, the majority of skippers had a medium educational level (52%), and a significant portion had low educational level (30%). It was not possible to know the educational level of crew members.

Demand of target species

Although the concrete records of the target species demand were not available, it is possible to describe the demand tendencies of the target species. Both striped venus and razor clam are extremely requested from Spain, hence almost all the captures performed are exported to Spain. Donax clam is consumed by the local population and is exported to Spain as well. Surf clam is normally consumed locally only.

Supply of target species

The target species of dredge fisheries are not caught by commercial fleets in Portuguese territorial waters and are not produced in aquaculture. Imports of surf clam from Vietnam exist, but the proportion of those imported goods in the Portuguese market is not known.

First sell price

The average first sell price of target species in wholesale market is shown in Table 2.

Table 2. Average price of target species in wholesale market (€/kg).

	2001	2002	2003	2004	2005	2006	2007	2008
Surf clam	0.55	0.75	0.59	0.50	0.50	0.51	0.50	0.89
Donax clam	1.54	1.56	1.57	1.57	1.56	1.56	1.59	2.30
Razor clam	1.89	2.00	-	1.50	1.90	2.00	-	-
Striped venus	1.49	1.50	1.44	1.50	1.50	1.50	1.50	1.51

The prices of surf clam and donax clam stayed almost unaffected between 2001 and 2007, and both present an ascent in 2008. The price of the razor clam suffers considerable oscillations due to the small quantities caught. No relevant price changes were observed in the period analyzed for striped venus.

Second sell price

It would also be important to know for each target species the difference between the price in wholesale market and in second sale. This would give an idea if the fishermen have organized themselves in order to market their products so as to ensure that a higher part of the catch value returns to them. The most usual case in artisanal fisheries is a highly concentrated distribution sector that earns the largest percentage of revenues.

Activity costs

While price information is readily available due to the existence of fish auction markets as a means of distributing the catch, information on the costs of fishing is extremely limited. It was only possible to get data of fuel costs, which is presented in Table 3.

Table 3. Fuel costs (Euros/m3). Source GALP.

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Average fuel price	246	298	312	373	493	546	550	678	492

The increase of fuel price during the period considered means a significant raise in the fishing costs.

Revenue from artisanal fisheries

The total revenue from dredge fisheries in Algarve is presented in Table 4.

Table 4. Total revenue of dredge fisheries (10^3 Euros).

	2001	2002	2003	2004	2005	2006	2007	2008
Total	798	1422	2140	1723	1795	1130	899	806

It is possible to conclude that between 2003 and 2005 the achieved revenue was significantly higher than in the remaining years analysed. The total revenue of each target species is summarized in Figure 4.

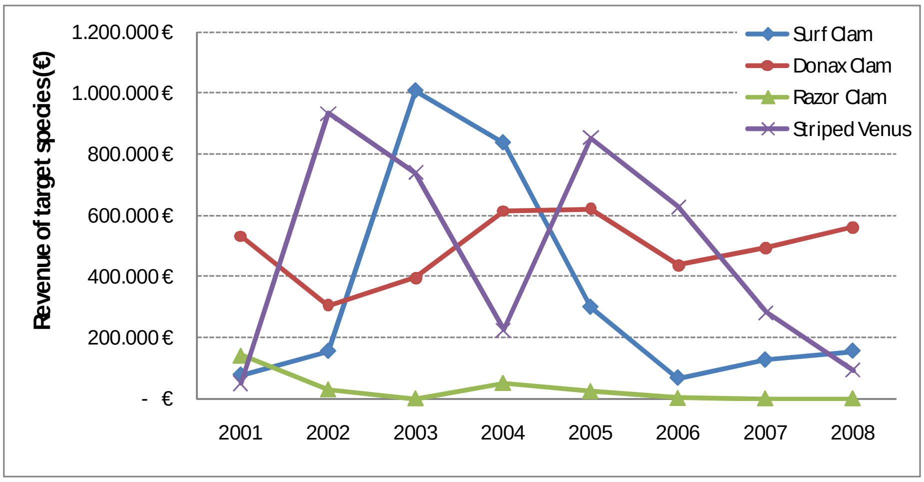

Figure 4. Revenue of target species (€).

The revenue coming from donax clam is the one which presents fewer oscillations over the years. Surf clam presented a maximum in 2003. Between 2003 and 2006 an abrupt decrease in its revenue was verified, after which a small recovery was observed. Regarding striped venus revenue, an inconstant behaviour has been observed. A decreasing tendency has been noticed since 2005. The achieved revenue due to razor clam catches is not significant in comparison with the dimension of profits of the other three species.

4.2. Pressures

Fishing effort

The number of performed fishing trips is summarized in Table 5. Only the trips for which the vessels landed the fishing haul in the wholesale market were counted in the statistics reported.

Table 5. Total number of fishing trips.

	2001	2002	2003	2004	2005	2006	2007	2008
Fishing trips	6291	7465	7740	8102	7732	5316	6582	5723

Comparing the total number of performed fishing trips in 2004 and 2008, one verifies that it suffered a significant decrease, although an increase was verified between 2006 and 2007. This tendency is in agreement with the diminishing of revenue: whenever fishermen perform less fishing trips, total revenue will diminish as well. The tendency of fishermen to perform fewer trips with dredge gears is a sign that this fishing art is becoming less attractive, probably due to the scarcity of biological stock. This issue will be further detailed in section 4.3.

Regarding the fishing area, dredge fisheries are allowed at depths exceeding 2.5 meters and must be held further than 300 meters from the coastline during the bathing season, as stated in the legislation (DR Portaria no. 1102-E/2000). In Portugal, dredge fisheries are mainly operated between 3 and 20 m depth (Constantino et al., 2009). The Portuguese south coast has four main harbours with registered dredge fishing vessels, presented in Figure 5: Faro, Olhão, Tavira and Vila Real de Santo António (VRSA).

Figure 5. Portuguese south coast harbours with associated dredge fishing vessels and respective fishing area.

Dredge fishing fleet operates from these four harbors, in order to decrease navigation time between the harbor and the bivalve beds. The Portuguese south coast between Cape São Vicente and Faro is not being exploited due to the rocky nature of the substrata or due to the deplection of bivalves stocks within that area. The total dredge fishing area is estimated on 310 km^2, where 65 km^2, 32 km^2, 88 km^2 and 125 km^2 belong to Faro, Olhão, Tavira and VRSA, respectively.

Fishing power

This analysis explored all vessels that operated with dredge gears in the south coast of Algarve. There were a total of 67 vessels that were licensed at least in one year between 2001 and 2008 (35 local and 32 coastal vessels). As some vessels may only have a dredge fishery license for some of the years analyzed, this resulted in an unbalanced panel data sample. The main characteristics of licensed vessels, in each of the years considered, are summarized in Table 6. The number of vessels has remained fairly stable between 2001 and 2008. Regarding the crew size, data is available only for 2005, and it is not known its variability during the period analyzed. The average power and GRT of vessels presented an increase which is related with the acquisition of newer vessels. The noticed increase on vessels' licenses can be associated to the legislation that simplified the fishing licenses process from 2008, giving to fishermen more flexibility in the choice of fishing gears.

Table 6. Main characteristics of vessels.

	2001	2002	2003	2004	2005	2006	2007	2008
No. of vessels	50	52	54	59	53	53	54	52
Crew members	--	--	--	--	3	--	--	--
Vessels power (kW)	42.8	43.1	43.0	43.8	46.3	46.3	46.6	46.7
Vessels GRT	3.6	3.6	3.6	3.8	4.0	4.1	4.2	4.2
Vessels length (m)	7.0	7.0	7.0	7.1	7.3	7.3	7.4	7.3
Vessels age (years)	13.7	14.1	14.6	14.1	13.2	13.4	13.9	14.4
Av. no. licences	2.4	2.7	3.2	3.2	3.6	3.5	3.5	4.1

Declared Catches

Table 7 summarizes the annual amounts landed of each species, in tonnes. The tendencies verified in the quantity of landed fish are in accordance with the revenue values previously presented. Between 2003 and 2004 extremely high quantities of surf clam were captured, since the biological stock of this specie was especially abundant. Striped venus also presented capture maxima in 2002 and 2005, that can also be related with the available biological stock. Donax clam captures does not present significant changes. As it was already pointed out, the razor clam is not a significant specie due to the lowest amount of captures.

Table 7. Annual quantities caught (in tonnes).

	2001	2002	2003	2004	2005	2006	2007	2008
Surf Clam	139	204	1699	1670	591	132	250	174
Donax Clam	345	196	251	391	397	280	310	243
Razor Clam	75	15	0	34	12	0.4	0	0
Striped Venus	33	622	514	149	568	717	187	61
Total	592	1038	2464	2244	1569	830	746	478

Non-complying with legislation catches

The existence of illegal catches is known, but the quantification of its level is difficult since the fishermen hardly assume this practice. The main motivation to perform illegal catches is the escape of the taxes, and the possibility to overfish, since the stocks are regulated daily.

4.3. State

For the state indicators it was only possible to collect data of changes of target species abundance and the mean size of target species. In this case study the levels of biotoxins are important and considered as natural contamination.

Changes in target species abundance

The abundance of target species is measured by a biomass indicator (g per 5 minutes of tow), and is presented in Figure 6.

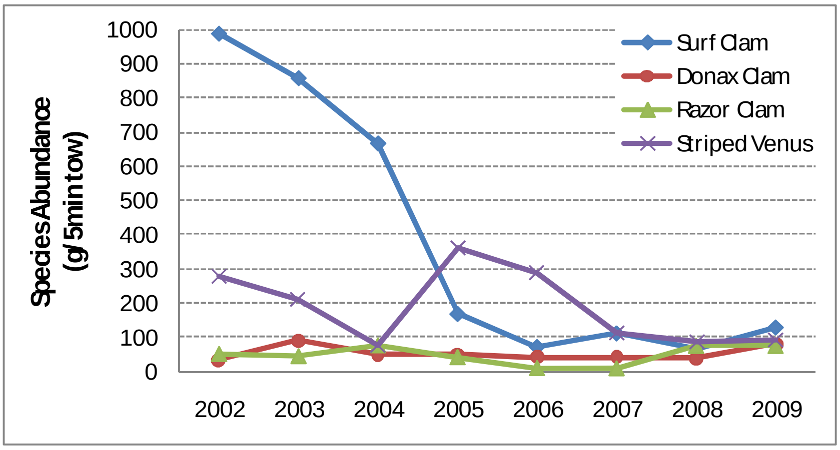

Figure 6. Evolution of biological stock levels (g/5min tow).

The biological stock of surf clam presents a decreasing tendency between 2002 and 2006, showing a stabilising tendency since 2007. Donax clam presents a stable biological stock, however a small ascent is noticed in 2009. Razor clam had some variations and presented a very low biological stock in the years of 2006 and 2007. Striped Venus biological stock peaked in 2005, and has been declining ever since. The relation between the decrease of the biological stock of target species and the decreasing in the number of fishing trips performed is clear, whenever fishing trips stop to be profitable this activity starts to be less attractive for fishermen. However the inverse perspective is also important to notice, whenever fishermen overfish target species (and sometimes this occur through non-declared catches), the biological equilibrium tends to disappear.

Contamination

The biotoxins level can describe the bivalve contamination with microalgae toxins. These can constitute a threat to human health, causing poisoning after the consumption of contaminated bivalve. In the south coast of Portugal, there were verified some episodes of bivalve contamination with Paralytic Shellfish Poisoning (PSP) toxins in 1992, 1994 and 1995, and with Diarrhetic Shellfish Poisoning (DSP) toxins between 2003 and 2006 (Vale et al. 2008). The species where this contamination was verified are Donax Clam (DSP and PSP) and Surf Clam (PSP). In Portugal, a regular monitoring program is implemented since 1986 for PSP toxins, since 1987 for DSP toxins, and since 1996 for Amnesic Shellfish Poisoning (ASP) toxins (Vale et al. 2008). Regulatory limits for the biotoxins levels (regulation EC 853/2004) are: 80 µg STX equiv. / 100g for PSP, 16µg OA equiv. / 100g for DSP, and 20 µg DA /g shellfish meat for ASP. It would be interesting to know the concentration of other types of contamination such as pollution; unfortunately this information was not available.

Mean size of target species

Regarding the mean size of the target species, significant changes were not verified, as it is described in Table 8.

Table 8. Mean size of target species (mm).

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Surf Clam	26	22	26	24	21	23	22	20	24
Donax Clam	27	29	31	32	31	28	27	29	29
Razor Clam	104	83	98	105	100	99	89	69	90
Striped Venus	26	21	25	23	21	22	21	22	25

4.4. Impacts

For the proposed impact indicators, it was possible to calculate the catch per trip and the costs per trip (considering fuel costs only). These indicators are presented together in Table 9.

Table 9 – Impact indicators.

	2001	2002	2003	2004	2005	2006	2007	2008
Catch per trip (kg)	94	139	318	277	203	156	113	84
Costs per trip (€)	299	279	304	341	458	694	606	--

As it was expected, maxima of captures were verified in 2003 and 2004, which correlates well with the data presented in the declared catches sub-indicator (section 4.2). The increase in the costs per trip was also expected, since fuel is the only considered cost (its evolution was already presented in the activity costs sub-indicator, section 4.1).

4.5. Responses

Subsidies

The European funds are transferred for the national authority. These funds are distributed competitively, to which the fishermen can apply their vessels for maintenance purposes. It wasn't possible to get the data of total amount of money subsidized for this fishery.

Educational programs

There are mandatory courses of professional instruction for fishermen. They were accomplished 2679 courses in 2008 and it is foresee that 6376 courses will be performed till the end of 2009, for the entire Portuguese fish sector (DGPA, 2008), but there is no information regarding how many dredge fishermen has accomplished them yet.

Legislation

The Portuguese legislation began to define limits of daily capture for each target species and per vessels type from 2001 onwards (DR Portaria no. 543-D/2001; DR Portaria no. 1072/2002; DR Portaria no. 230/2003; Portaria no. 688/2005). These limits are summarized in Table 10.

Table 10 - Limits of daily captures per species and per vessels (kg).

		2001	2002	2003	2004	2005	2006	2007
Per vessel	Until 1,8 GT	110	75[1]	75[2]	75[2]	145	145	145
	Between 1,8 and 2,8 GT	165	110[1]	110[2]	110[2]	215	215	215
	Between 2,8 and 3,8 GT	210	140[1]	140[2]	140[2]	275	275	275
	More than 3,8 GT	300	200[1]	200[2]	200[2]	390	390	390
Per specie	Surf Clam	200	200	400	400	225	225	225
	Donax Clam	220	150	150	150	150	150	150
	Razor Clam	100	50	50	50	30	30	30
	Striped Venus	100	200	200	200	250	250	250

[1] These limits shall be increased by 50% if more than half of the catch is of surf clam (*Spisula Solida*).
[2] These limits shall be increased by 200% if more than half of the catch is of surf clam (*Spisula Solida*).

The incentives given by Portuguese legislation can be related to the sharp increase in surf clam catches compared with other target species, for the years of 2003 and 2004 (see Table 7). It is defined by legislation an interdiction period between May 1 and June 15 (DR Portaria no. 419-B/2001), which represents an interdiction period of 46 days per year. In 2006 the interdiction period was between March 1 and April 30 (DR Portaria no. 208-A/2006). Extraordinary interdictions are imposed when episode of biotoxins occur. In addition, if the biological stock of species is very low, the fisheries can also be interdicted for that species (e.g., this occurred for two months, in March and April 2006, for all the target species of dredge fisheries in the south coast of Portugal, see DR Portaria no. 208-A,/2006). Fisheries are allowed six days per week (between Sunday and Friday) and each vessel can make a single trip per day.

Technical characteristics of dredge fisheries are well regulated and actualized. Vessels used for dredge fishing are limited to a maximum power of 73,5 kW (DR Portaria no. 254/2008). The maximum width of the dredge mouth is 1 meter and the interval among teeth should be always larger than 15 mm, both for GD and TD (DR Portaria no. 1102-E/2000). Legislation for the GD (DR Portaria no. 1423-B/2003) specifically establishes that grid bars must be metallic and parallel, disposed in the direction of the length. The bars can have a maximum length of 125 cm, a maximum height of 50 cm and a maximum width of 80 cm. Other relevant regulations for dredge devices are summarized in Table 11, according to target species (although TD is essentially used for targeting razor clams, the minimum size of the mesh of the net bag is regulated for all the target species).

Table 11 – Regulated characteristics of dredges according to target species (DR Portaria no. 1423-B/2003)

Species	Length of the teeth (GD and TD)	Distance among bars (GD)	Minimum size of the mesh (TD)
Surf Clam	200 mm	≥ 12 mm ± 0,5mm	≥ 30 mm
Donax Clam	200 mm	≥ 8 mm ± 0,5mm	≥ 30 mm
Razor Clam	550 mm	≥ 9 mm ± 0,5mm	≥ 30 mm
Striped Venus	200 mm	≥ 12 mm ± 0,5mm	≥ 30 mm

5.Conclusions

DPSIR framework gives a multidisciplinary viewpoint of the system under analysis, using indicators that describe both the system and the cause effect relationships between environment and human actions. This methodology also provides main stakeholders with organized and simplified information, which can support management decisions. In this paper the DPSIR framework was explored to describe generically the artisanal fisheries in the Atlantic Arc. With this motivation a set of DPSIR indicators were selected and proposed. The driving forces were perceived as the socio and economic motivations for the existence of the fishing activity, and pressures as the human actions that have the potential to stress the environment. The state was defined as the temporal changes of the exploited ecosystem and impacts as the economic and social negative effects of the fishing activity. Finally, responses included the measures performed by society with aim to improve the whole system (socially, economically and environmentally). A particular case study was also carried out, where the proposed set of DPSIR indicators was applied - the artisanal dredge fisheries in the south coast of Portugal, Algarve. Because some data was not available, some indicators could not be properly developed. To enhance this analysis and the knowledge of dredge fisheries, future data collection is desirable.

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