Long-term trends in small pelagic and bottom fisheries in the Mediterranean: 1950-2008

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Final version

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Summary

In its programme of work, Plan Bleu has undertaken an economic analysis of the ecosystems of the Mediterranean Large Marine Ecosystem, in the general framework of implementation of the Ecosystem Approach in this Sea promoted by the Mediterranean Action Plan. To that effect, Plan Bleu has undertaken an assessment of the sustainability of maritime economic activities in the Mediterranean (MedSEA Project) The present report is a contribution to the project. Its purpose of this study is to provide the Mediterranean Blue Plan project with a synoptic view of the state of fisheries development in the Mediterranean and therefore indirectly of the likely state of the underlying resources. The study is particularly timely as the concern has been growing in international instances about the state of the resources and the GFCM has been stressing repeatedly the concerns about the resources (based on scientific assessments) and the need to start seriously regulating capacity, effort and catches.

The study analyses the state of the fisheries looking at trends in landings and landing growth rates for the key resources of the Mediterranean. It does so at the level of the Mediterranean, the different GFCM statistical areas, and the countries (Home Areas). It could not do it using the recently management areas adapted by the GFCM (the GSAs) because there are still no time series available (at least publicly) for that purpose.

The data is taken from the FAO Fishstat databases for the FAO Fishing Area 37 –Mediterranean and Black Sea 1950-2008 (taking out the Black Sea data) and the GFCM data set for 1970-2008. From this data, key groups of species were selected using the ISSCAAP categories to reflect the fisheries on bottom fish (on the shelf and the slope) as well as small pelagic species. Sharks and rays, lobsters, shrimps and prawns as well as squids, cuttlefish and octopus were included. Tunas and tuna-like species as well as species such as coral, turtles, cetaceans, tunicates, etc. were not analysed.

The methodology rests on the use of the fishery development cycle (sensu Garcia 2009) already used for the World Bank review of the state of world fisheries. This cycle analyses the landings in terms of progression in the development cycle from Development to Maturity and eventually to Senescence and, sometimes, to Recovery. The main assumption is that the trends in landings, despite all the alledged and real problems with their quality, reflects mainly the impact of the fishing fleets, particularly during the main fishery development phase between 1960 and 1990. The method compares the landing variable with the Long Term Maximum Average Yield (LTMAY) to identify the periods of growth (Development), stagnation (Maturity) and decline (Senescence). The numerous graphs produced with the time series are analysed one by one and then summarised in a synaptic representation that gives a global perception of the development processes, allowing fruitful comparisons of the empirical between resources, areas and countries, looking for contrasts or coherence and overall diagnosis.

At Mediterranean-wide level, the data show an overall stagnation for 2.5 decades of the aggregated production (about 800,000 tonnes). The pelagic low value species show the same pattern (and are stable at 500,000 tonnes) while the bottom high value fish increase until 1990 to close to 300,000 tonnes and decline rapidly until 2008.

At regional level, the 8 GFCM sub-areas show different behaviour. The different resources increase in some areas, stagnate in others and decrease still in others. There are some general patterns:

1) The fisheries appear generally in more advanced stage of development (and unfortunately of senescence) in the western and northern Mediterranean than in its southern and eastern parts.

2) In general, pelagics resources appear less pressurized than demersal ones as one would expect considering the higher economic value of the second. Also, among the high value resources, lobsters appear more pressurized and less able to sustain maturity situations. Similarly, sharks and rays appear extremely pressurized for the entire period, probably with a collapse of all targeted fisheries in the 1960 and repeated cycles of development-maturity-senescence. Shrimp resources are in a better shape and are still increasing and perhaps reaching their maximum. The same

seem to be happening with cephalopods. For all these resources the entry in "Maturity" and senescence happens earlier in the North and West and maturity stages tend to be shorter also in these regions.

At national level, the same general pattern prevails with some intriguing differences. The overall trend in development pressure from West to East is clear. However, the pelagics seem to have started reaching maturity earlier than the demersals even if the latter have reached a high percentage of country fisheries in senescence in recent times.

Although the study was not planned to make a full comparative analysis of the study results with conventional assessments made in the ambit of GFCM, a few comparisons with recent reviews indicate a general coherence (e.g. in the degree of overfishing in demersal and pelagic stocks) and there is evidence that the landing trends analysis reflect the underlying fisheries dynamics and their interaction with the resources.

This indicates that the approach can be useful, particularly but not only, where more scientific data is scarce. Having a more complete coverage in time and space, if carefully used, it can provide a useful backdrop to more sophisticated assessments. In area with limited scientific capacity, it can be used to promote a dialogue between the scientists, the policy-makers and the sector with the view to better understand the fisheries sector past history, and present likely state.

I. Introduction

In its program of work, Plan Bleu has undertaken an economic analysis of the ecosystems of the Mediterranean Large Marine Ecosystem, in the general framework of implementation of the Ecosystem Approach in this Sea promoted by the Mediterranean Action Plan. To that effect, Plan Bleu has undertaken a regional analysis to estimate the economic value of the sustainable benefits obtainable from Mediterranean marine ecosystems. This study will be followed by an assessment of the sustainability of maritime economic activities in the Mediterranean (MedSEA Project). Moreover, Plan Bleu is committed to draft a section of a report the elaboration of which has been undertaken in the framework of an initiative aiming at placing the Mediterranean environment at the heart of public policies, through the use of relevant methods of economic analysis. That section of the report deals with fisheries. It will follow the methods developed by this author for the World Bank in an assessment of the state of the world fishery sector (Garcia 2009). This report, commissioned by Plan Bleu, will contribute to the exercise and is aimed at characterizing the degree of maturity of the different national and regional fishery sectors of the Mediterranean, based on the landings formally reported by fishing nations to FAO.

Fishery resources are part of the human environment and this study intends to contribute to the understanding on the state of their resources. Conventional stock assessments of a few sets of target resources have been conducted for decades at national level and within the Working Groups of the General Fisheries Commission of the Mediterranean (GFCM). However, these analyses are necessarily limited in scope to a few target species and cannot easily be extrapolated to provide a comprehensive view of the Mediterranean fisheries across resources categories, areas and countries for which landings data is the only material presently available. The present study intends to provide the strategic overview against which the conclusions of a limited number of stock assessments might be examined and eventually extrapolated to the whole set of resources.

The state of Mediterranean resources and fisheries is regularly examined, e.g. within the State of Fisheries and Aquaculture (SOFIA) published every two years by FAO and in GFCM reports[1]. The Commission, through its stock assessment working groups and statistical unit, is promoting a common metric for the state of fisheries as this could assist countries to gauge them in similar and comparable ways, showing their progress towards maintaining or restoring fishery resources and hence, the performance of their policies in that respect. The last resources review by FAO (2010: 41) indicates briefly that "*In the Mediterranean Sea, the overall situation has remained stable but difficult since the last global assessment. All hake (Merluccius merluccius) and red mullet (Mullus barbatus) stocks are considered overexploited, as are probably also the main stocks of sole and main seabreams. The main stocks of small pelagic fish (sardine and anchovy) are assessed as fully exploited or overexploited.* However, a large numbers of fisheries and resources are not regularly assessed and hence do not benefit from the information that would be required for an effective management. The most recent review of the European demersal resources (EVOMED 2011) confirms the very significant increase in fishing power and capacity since the 1950s in the European Mediterranean countries and provides some analysis of abundance trends during the last 20 years pointing to important declines in some bottom species (particularly the red mullet *Mullus barbatus* as well as sharks and rays) and increases in abundance of shrimps and cephalopods.

The FishStat Plus database of landings, for example, includes about 160 taxonomic entities corresponding to the landings categories selected for this study, i.e. excluding entities such as: marine plants, algae, mussels, oysters, mammals, corals, tunas and tuna-like fishes, Sea urchins, turtles, etc. Considering the number of countries in the Mediterranean and accepting that all species do not exist in all countries, this indicates that Mediterranean fishery resources consist probably of many hundred separate stocks or populations, discrete enough to be managed separately, and it is clear few stocks only are assessed every year at species level and many species have never been assessed at all and may never be before it is too late.

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[1] Fishery resources fact sheets for the GFCM are indeed maintained by the Commission on its website http://www.gfcm.org/gfcm/topic/17104/en

This suggests that in order to measure progress towards the objectives of the WSSD Programme of Implementation to "*restore stocks to levels that can produce the maximum sustainable yield*" by 2015, complementary, simpler and more aggregated indicators and proxies are necessary. In addition, as fishing capacity can often move rapidly between resources, indicators at sector or sub-sector level are needed to complement the stock-by-stock conventional assessments. Landings data is the main information available in practically all countries and despite their known shortcoming is a tempting material for analysis, particularly when long time series are available. The fact that long term series of landings reflect natural climatic oscillations (decadal changes) is an indication that, at such time scales at least, catches reflect the evolution of biomass. It is therefore tempting to believe that, at that scale, they also reflect fisheries development even though, as usual, distinguishing the impacts of the two drivers (climate and fisheries) is difficult if not impossible without additional information.

Efforts in that direction were undertaken more than two decades ago. Garcia (1984) used the Mediteranean fisheries data as an example of application of composite production models. Grainger and Garcia (1996) analysed the resources trends in the FAO landings data, aggregated by main resource types, to produce a global and regional assessment that included the Mediterranean. Garcia (2009) extended the latter approach to an area-based analysis of the state of fisheries in the world as a whole and in its oceans, regions and countries. The same approach is extended in this study, presenting and analysing the data aggregated at the level of the Mediterranean, the main GFCM sub-areas, and the coastal countries.

The analysis provided in this report may help Mediterranean countries understand their impact on the natural resources over which they have jurisdiction and responsibility and assist them in their efforts to improve accountability and stewardship. It also promotes the identification of information gaps and underscores the importance of investments in the scientific underpinnings of fisheries management, in better statistics, and in improved knowledge and transparency.

Report structure

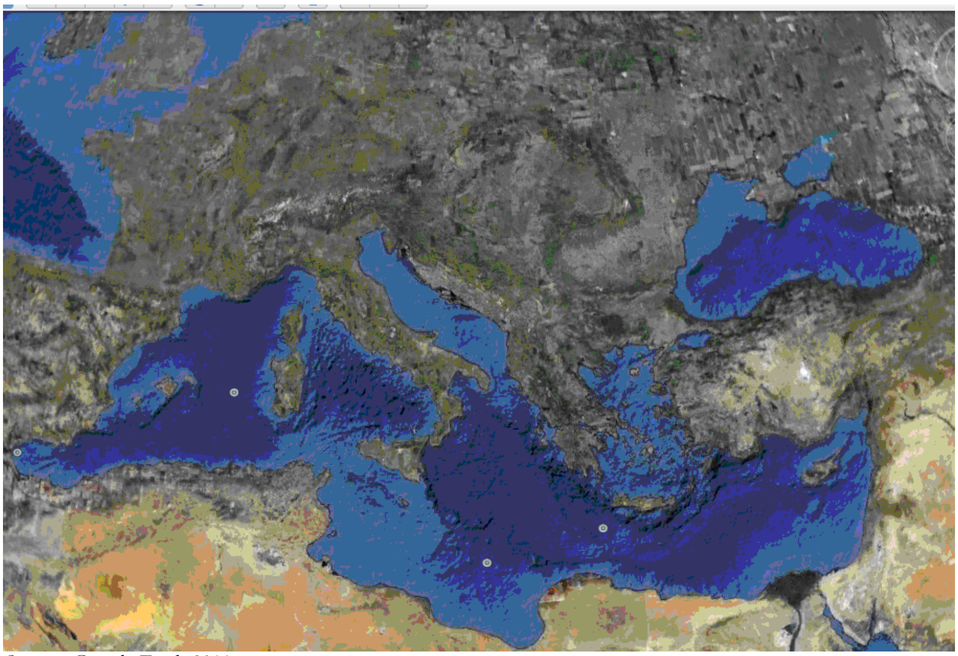
In the following sections, the report describes the geographical framework of the study and the different levels at which the analyses are conducted as well as the data used and the methodology adopted. The development cycles of the selected resources categories are described at the level of: (i) the entire Mediterranean, the GFCM statistical sub-areas and the countries, presenting first the separate cycles and then combining them into synoptic representations showing the state of development of the resources at these various scales. The relation between the development cycles and the state of the underlying resources that sustain such development and are impacted by it is discussed and the study conclusions are briefly compared with those of more conventional (but more limited) assessments. The discussions provides at the end of the report address the limits of the study in terms of data and methodology. The conclusion summarizes the findings and their implications. Somme additional material drawn from Garcia (2009) and considered useful for the understanding of the methodology, are given in Annex (with the permission of the World Bank). The large number of detailed development cycles that have been drawn and served to develop the synoptic graphs are grouped in Plates annexed to the report.

A word of caution

The results contains in the report should be considered as preliminary and intending to provide a preliminary nested comparative analysis of the Mediterranean fisheries based practically exclusively on the description and examination of reported marine fisheries landings. Because of this, the analysis inevitably suffers from the likely limitations of these data. It also relies on a hypothesis that the long term trends in these landings statistics reflect the development of the sector on an evolving (geographically expanding and ecologically changing) resource base. The hypothesis and the metrics presented are to be considered preliminary and, although some level of validation is already provided in the report, based on a small sample of the available literature, they would certainly benefit from additional considerations and testing at country level, using the more detailed information available to national fisheries authorities and civil society. It is therefore strongly cautioned that the results presented in this report should only be taken as a means of framing a constructive dialogue at national level on fisheries' impact on resources and on their optimization within the principles of sustainable use. The preliminary conclusions should ideally be tested and supplemented at country-level by additional sector-wide analyses as well as stock-specific analyses of the major commercial fisheries.

II. Geographical framework

Figure 1: The Mediterranean and the Black Sea.



Source: Google Earth 2011

1. Statistical divisions

The study covers the Mediterranean Sea *sensu stricto*. It excludes the Black Sea and the Sea of Azov. While generally considered part of the Black Sea system, the Sea of Marmara has been included in the study, because of the similarity of its long term trends with that of the Mediterranean. The study covers, therefore, the following GFCM Mediterranean sub-areas, from West to East: 1.1-Balearic islands; 1.2-Gulf of Lion; 1.3-Sardinia; 2.1-Adriatic; 2.2-Ionian; 3.1-Aegean; 3.2-Levant and 4.1-Marmara.

The GFCM has also subdivide these sub-areas further in 28 smaller Geographical Sub-Areas (GSA) with the view to have an analytical framework better suited to more specific resources and fishery assessments and more uniform management units. However, these could not be used for this study as there is not yet any long-term catch database for these smaller subdivisions of the Mediterranean.

2. Jurisdictions

The Mediterranean is a semi-enclosed sea with intense maritime traffic. Following the 1982 adoption of the UN Law of the Sea Convention (LOSC), its coastal states have shown restraint over their rights to extend national jurisdiction, owing to difficulties of delimitation in a narrow sea and the need to preserve freedom of navigation. Most Mediterranean states (except Greece, Turkey, Bosnia and Herzegovina, and Slovenia) have established a 12-mile territorial sea. Syria claims an anomalous 35-mile territorial but it is not clear whether it enforces it beyond 12 miles. Morocco has established its EEZ in 1981 but it is not clear that it is enforced in the Mediterranean side of the country. Egypt declared an EEZ 1983 but the declaration has not been followed by implementing legislation. Croatia adopted several provisions on its EEZ in 1994 but the process has not been completed. Spain and France have proclaimed a 200-mile EEZ off their coasts but have indicated that it is not applicable to Mediterranean waters. It appears therefore that there are not yet any EEZ clearly in force in the Mediterranean.

Some countries have claimed exclusive fishing zones extending beyond their territorial waters: Algeria (1994, 32 miles in the West and 52 miles in the East), Malta (1978, 25 miles) Tunisia (1951, down to the 50 meters isobath resulting in 15 to 75 miles depending on the area) and Spain (1997, 37 miles but without fisheries protection zone in the narrow Alboran Sea. The Gaza strip and West Bank has also a 20 miles fishing zone extending from a 3 miles coast. (Eastmed 2010). The 2002 European Union Community Action Plan for the conservation and sustainable exploitation of fisheries resources in the Mediterranean advocated the declaration of fisheries protection zones of up to 200 nautical miles and France appears to be preparing for the declaration of a 50-mile fisheries protection zone in the Mediterranean. Such declarations have legal implications on jurisdiction over fisheries resources, reduce the area of high seas and modify the access rights to certain fisheries.

3. Distribution of fishing activities

In reporting their landings to FAO, following international standards agreed at the international Coordinating Working Party (CWP), Mediterranean fishing nations indicate the FAO statistical area or sub-area of origin of the landings but do not specify whether they originate from inside their territorial waters, or any other formally defined zone. In any case, bottom fish resources are mainly exploited on the narrow shelves, the shelf break and the upper slope down to 500 meters. *Fishing areas are limited to around the beach or port of base, the time devoted to the fishing activity is generally short, in many cases during the night (purse seiners and some artisanal boats) or day for trawl fishing. Even in cases of several days trips, it is unusual that fishing takes place far from base* (Bas Pereid 2006). However, longer trips, farther from ports are also undertaken, e.g. in the Ionian and Aegean Seas by Greek Vessels (European Union 2011). Small pelagic resources such as anchovies and sardines use coastal nurseries and adults generally live over the shelf and close to the shelf break forming essentially local concentrations with little or no long range migrations. Mackerel and horse mackerel are distributed more offshore than sardines and anchovies and may undertake more extensive migrations within and perhaps between sub-areas.

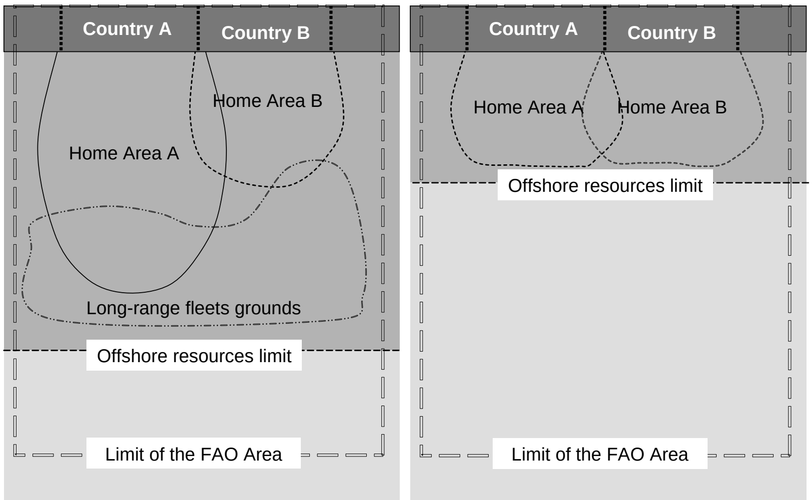
Coastal states have therefore historically exploited the waters in front of their own coast: They may make some incursions in waters of neighbouring countries (e.g. Spanish vessels in the "French" part of the Gulf of Lion, on the slope and deep shelf grounds). They may also fish occasionally in the deeper waters of the countries facing them on the other side of the narrow Mediterranean (e.g. Spanish fishing off the Moroccan and Algerian coasts or Italians fishing off the Yugoslavian, Tunisian, Libyan and Maltese coasts). The extent to which this behaviour may have decreased in importance during the last decades as the neighbouring countries developed their own fleets, reducing the abundance "premium" for the foreigners, and improving management, is not known. The GFCM database reports some bottom resources landings by Spain in the Ionian (2006-2008), Levant (2007-2008) and Sardinia (2001-2008) sub-areas; and some landings by Portugal (since 2000) and Japan (only sharks) in the Balearic sub-area. These indicate some limited activity by powerful fishing nations out of their base sub-area but does not give any idea of the fishing activity of these nations in the waters of their neighbours in that sub-area.

Globally, the trends in reported landings (with the usual caveat about their quality and the problem of discards) should therefore largely reflect the evolution of the national fisheries impact on the resources in the immediate national surroundings. Bas Pereid (2006: 380) stresses indeed that, *today, fishing is in general restricted to a rather limited area which is mainly around the main landing ports.*

4. The concept of Home Areas

The landing statistics in the Fishstat database refer to the Mediterranean as a whole (for the 1950-2008 database) or to the GFCM statistical sub-areas (for the 1970-2008 part of the database). As a consequence the catches, reported as coming from a statistical division, may not be coming from the national EEZ (which in any case do not really exist in the Mediterranean) or from the national fishing zone (when there is one). In addition, fisheries are dynamic activities that can and do expand their range with time. Keeping in mind these realities, Garcia (2009) used the concept of Home Area, defined as the dynamic area from which the landings originate all along the time series (**Figure 2**). It is the area to which national fleets have access during the fishery development process. It is not assumed that such area has been constant. Indeed, it is suspected and sometimes known that it is not and that it has expanded with time, most often towards deeper waters. The total Home Area of the fishing sector of a country may overlap many GCFM sub-areas. Such country would therefore have several Home Areas that can be analyzed separately, particularly if they belong to different ecosystems. This is certainly the case of Italy, Greece and Turkey and to some extend also of Tunisia. This detailed analysis by smaller Home areas was not undertaken in this study and would certainly be recommended for similar analyses done at national level.

Figure 2: relation between FAO Areas and Home Areas.



Source: Reproduced from Garcia 2009. Courtesy the World Bank
Note: In dark grey, the extension of the resources, often corresponding to the end of the shelf.

The landings reported by a country to FAO are taken to reflect to some extent the state of the composite resources living in the Home Area, but not necessarily in the total GFCM sub-area concerned[2]. While in most cases, catches in one Home Area are taken essentially by the coastal country bordering it (**Figure 2, right**), some Home Areas (possibly where the shelf is the largest as off Tunisia and Libya or in the Ionian Sea) may also be affected by some long-range fishing from neighbouring countries (**Figure 2, left**).

The countries bordering the Mediterranean have all been included in the analysis. Data are available since 1950 for 16 countries (Albania, Algeria, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Morocco, Spain, Syria, Tunisia and Turkey) as well as for the Socialist Federal Republic of Yugoslavia and the coastal countries emerging from its dissolution in 1990 (Croatia, Bosnia and Herzegovina, Serbia and Montenegro and Slovenia). The time series of the latter countries, broken or starting in 1990, is insufficient for an analysis on long-term trends and, as a consequence, the data have been pooled in a category named the Former Yugoslavia Area (FYA). The landings of Gibraltar, Monaco and the Palestine Occupied Territory are either very small and erratic or available only recently. They could not be analyzed separately in any detail but are included in higher level totals by area or taxonomic groups.

In order to have maximum contrast in the data, the analysis by country was conducted using the Fishstat dataset for Area 37 (1950-2008) in which the data is not subdivided by sub-areas. For all the countries bordering the Mediterranean except Turkey, the reported landings come from the Mediterranean. In the case of Turkey, the 1950-2008 data had to be corrected to eliminate the landings coming from the Black Sea (**section 4.3.1**).

The analysis has proceeded from the global level to the regional and country level and from the total of the selected resources to each resource category. The progression of the analysis from the global level (at the Mediterranean Large Marine Ecosystem level) to the sub-regional and country level is intended to nest the country-level diagnostics within coherent regional diagnostics in order to better understand the local sources of the global patterns and their changes, facing however the expected increase in "noise" at the lower levels of aggregation.

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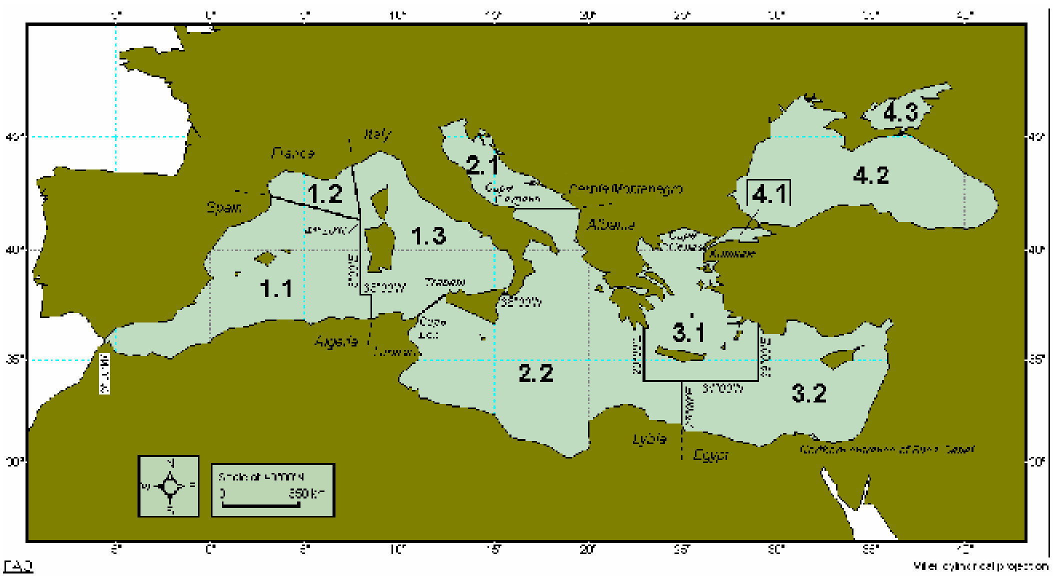
[2] The correspondence between the two depends on how mobile the resources are.

III. The data

1. Data source

Figure 3: FAO-GFCM Major Fishing sub-areas in the Mediterranean and Black Seas.



Note: 1.1 Balearic Islands; 1.2 Gulf of Lion; 1.2 Sardinia; 2.1 Adriatic; 2.2 Ionian; 3.1 Aegean; 3.2 Levant; 4.1 Marmara.

The data used has been extracted from the FAO Fishstat Plus data base[3], specifically the Capture Production dataset for the FAO Main Fishing Area 37- Mediterranean and Black Sea (1950–2008) and the GFCM database (1970-2008). The two databases are similar at the aggregated level for the years they both cover. However, the GFCM database provides sub-regional resolution as it identifies the GFCM sub-areas from which the landings come. Both databases are compiled from information provided to FAO by fishing nations following a formally agreed reporting format within an agreed system of statistical subdivisions delimited in the 1970s based on the ecological information available at that time (**Figure 3**). Fishstat Plus provides the only global and publicly accessible dataset on formally reported fishery landings. The information is provided in accordance with internationally agreed protocols of the international Coordinating Working Party on Fishery Statistics (CWP)[4] and the reporting parameters affect the utility of the data for the purposes of describing the level of development of national fisheries and drawing conclusions about the state of the underlying resources on a country-by country basis.

Notwithstanding the known and alleged limitations of the official landings data (see discussion in **section 6.1**), the Fishstat dataset has been shown to contain information about the development trends of fisheries as well as climate oscillations that are consistent with other sources of knowledge on such trends (Grainger and Garcia 1996; Garcia and Newton 1997; Caddy and Garibaldi 2000; Garibaldi and Caddy 2004; Garcia 2009). It should therefore be stressed that that the different potential sources of error in the data are apparently not sufficient to significantly distort the main development trends, particularly in the 1950-1990 period of rapid growth of the world fisheries. With the slowing down of fisheries expansion since the 1990s, the importance of the climatic drivers is likely to start dominating confounding significantly more the effects of fishing and particular caution should be exercised in trying to interpret modern catch trends only in terms of fishing pressure.

3 Software and data available at http://www.fao.org/fishery/statistics/software/fishstat

4 http://www.fao.org/fishery/cwp/en

2. Selected resources categories

The GFCM database on bottom and small pelagic species contains information on about 160 statistical taxonomic categories corresponding to the species, genus, family or higher taxonomic level. These entities are further grouped into categories agreed as International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP). A significant proportion of the data (about 10% of the total landings) is reported to FAO as "Miscellaneous" or "Unidentified" fish. The landings are in metric tonnes, equivalent live weight.

This study is purposely limited to fisheries on conventional bottom and small pelagic fish resources that constitute the foundations of Mediterranean fisheries and for which the longest time series are available. The corresponding ISSCAAP categories were used as filters to extract the data from needed the FAO database to constitute the selected resources categories listed below.

Large pelagics, mammals and other highly migratory species have been excluded from the analysis as fisheries for these species tend to range throughout the Mediterranean LME and beyond and do not provide useful indicators of the state of the national fishery sector or of the local environment. Bivalves (e.g. oysters and mussels produced mainly by aquaculture) as well as turtles, corals, urchins, tunicates, etc. were also excluded. The landings (in metric tonnes, round weight) for two categories of resources (Bottom Fish and small Pelagic Fish) and their total landings were extracted from the Fishstat Capture Production datasets: (i) a Mediterranean dataset for 1950-2008 by taxonomic category and country; and (ii) a GFCM data set for 1970-2008 which is shorter but has a sub-area resolution. The resources categories were established as follows:

- Bottom Fish Landings (BL): ISSCCAP categories 31 (flounders, halibuts, soles), 32 (cods, hakes, haddocks), 33 (miscellaneous coastal fishes), 34 (miscellaneous demersal fishes). For the purposes of the analysis, it was assumed that category 33 contains essentially demersal and bentho-pelagic fish.
- Small Pelagic Fish Landings (PL): ISSCCAP categories 35 (Herrings, sardines, anchovies) and 37 (Miscellaneous pelagic fish). For the purposes of the analysis, it was assumed that this last category contains essentially small pelagic species.
- Other Marine Fish Landings (OL): ISSCCAP category 39 (Marine fishes not otherwise identified). It is suspected that this category contains essentially small individuals and species of the bottom fishes because small pelagics are usually caught and landed in large quantities and small number of species, easily identifiable and rarely sold as mixed species. Nonetheless, in the absence of a definitive clue, it was not considered possible to split these landings into bottom fishes and small pelagic fishes with any degree of confidence. The data were therefore kept separate.
- Total Fish Landings (TL): the sum of BL, TL and OL, i.e. the sum of the ISSCAAP Categories 31, 32, 33, 34, 35, 37 and 39.
- Sharks & Rays (SRL): ISSCAAP category 38 (Sharks, rays and chimaeras) from which chimaeras and related species were excluded;
- Lobsters (LL): ISSCCAP category 43 (Lobsters, spiny rock lobsters).
- Shrimps & Prawns (SPL): ISSCCAP category 45 (Shrimps and prawns).
- Cephalopods: ISSCCAP category 57 (Squid, cuttlefishes and octopuses).

The last four categories were treated separately the Bottom Fish category as they are considered as particular indicators. Sharks and rays are usually very vulnerable species because of their biology (long life, late age at maturity, reduced fecundity) and they tend to more severely impacted by intensive fishing. Lobsters are extremely high value species that are therefore targeted particularly intensively. Shrimps and cephalopods are preys that may indeed increase productivity when the Bottom Fish resources (which tend to be their predators) are overexploited. Including them in Bottom Fish could have distorted the trends in this category. Because of their small quantities and high variance, they were aggregated at sub-regional level and not analysed at national level.

IV. Methodology

1. The fishery development cycle[5]

The development phases of a fishery on a single species stock have been described as follows (see **Annex 1 Figure 1**): (1) *Under-exploitation*, with low catches and low effort; (2) *Growth*, or *Development*, with rapidly raising catches and effort; (3) *Full Exploitation*, with maximum catches and stable or increasing effort; (4) *Overexploitation,* with catches declining as effort increases; *Collapse*, with deep decrease in effort and catches, recruitment failure and economic collapse; and, if management is effective, *Recovery* which is indeed a new development phase (Larkin and Willimovsky 1973; Csirke and Sharp 1984; Grainger and Garcia 1996). In this model, the names are taken to reflect the state of the underlying stock. It is assumed that the level of fishing pressures drives the catches and abundance and that the trajectory is reversible by reducing effort pressure, easily before collapse, with more difficulty after it. The maximum catches observed are considered a rough estimate of the Maximum Sustainable Yield (MSY).

Garcia (2009), following more general considerations on business development (e.g. by Schumpeter 1939 and Marchetti 1987) considered that, at a more aggregated level, e.g. at species group, sub-sector, national, regional or global levels, fisheries, as most if not all economic activities, develop and decline in "business cycles" with phases of *Expansion*, *Crisis*, *Recession* and, possibly, *Recovery* reflecting the emergence of a business and its progressive saturation of the development space available to it. Grainger and Garcia (1996) have used this concept implicitly, looking at landing patterns of resource types aggregated at global or regional level and identified phases of *Development*, *Maturity*, *Senescence* and *Recovery*. The process, in this case, is not only related to fishing pressure but also to a complex set of changes in policies, technology, markets as well as natural resources fluctuations which are not easily separated and interpreted without additional information. In that process, the annual growth rate of the landings characterizes the different phases of the development cycle (**Figure 4**). They decrease on the long term as the fleets harvest reaches the maximum long-term potential that the area can offer. It is generally assumed that, with a time series covering the period since World War II, the longer-term trend reflects the progressive "colonization" and impact of the underlying resources by the fishery (see **section 6.4.1** for a full discussion on the matter).

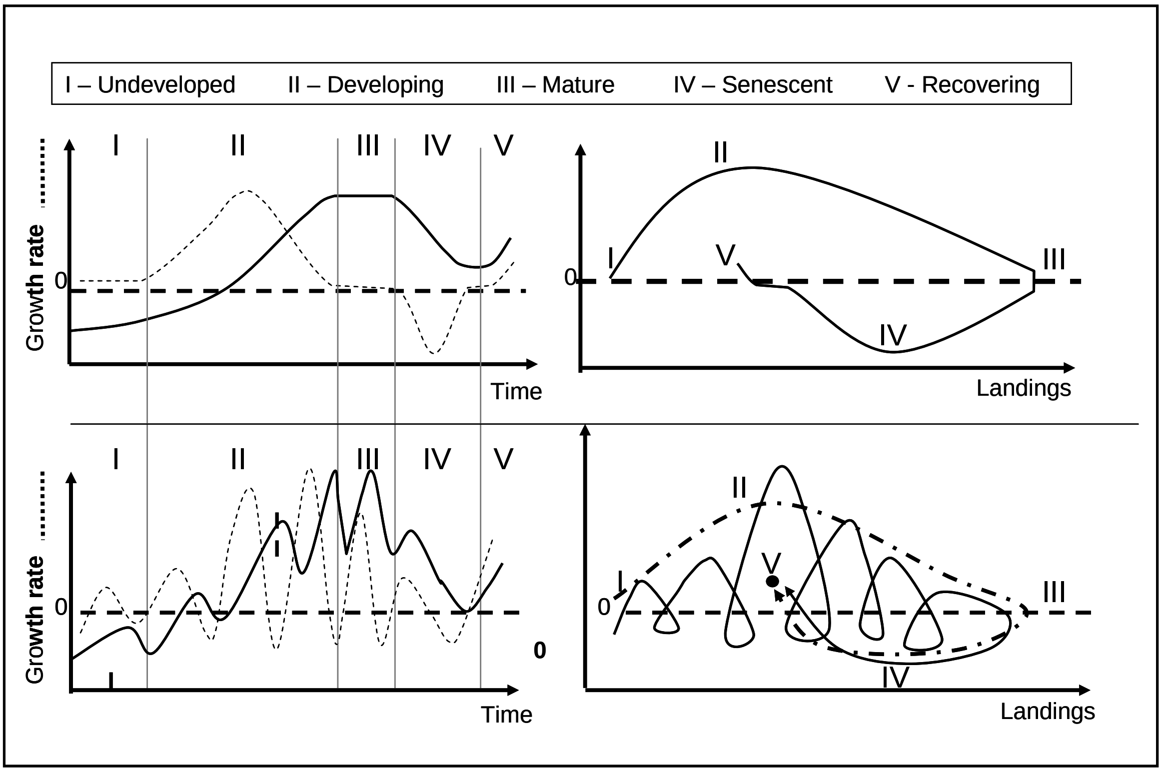
The rate of development of a fishery (measured here by the rate of growth of its landings) increases rapidly at the beginning of the growth phase. It is highest somewhere in the middle of that phase[6] and decrease with time towards zero as the potential for growth is used up. Albeit disturbed by medium-term fluctuations, this long-term pattern is clearly visible in most datasets. The Plates given in **Annex 3** contain numerous examples. The higher frequency fluctuations may be related to errors in the statistics collection or reporting systems, natural oscillations of the resource base or of the economic development opportunities. However, the long term trend towards some asymptote is most likely connected to the natural limits of the composite resource base and the progressive reduction with time of the number and size of stocks that are still able to produce substantial increases in landings. The long-term pattern and trends of the landings, thus indicates the pace at which the developing exploitation approaches its saturation point or, in other words, its operational maximum production under the prevailing economical and ecological conditions. The argument was used by Garcia and Newton (1997) as an indication that the world production was probably approaching its maximum potential at that time. The examination of the data available at aggregated level confirmed the general pattern shown in **Figure 4** top panel (see also **section 4.2).** At lower levels of aggregation, the importance of medium-term oscillations in landings increase leading to more "noisy"

[5] This section draws heavily on Garcia (2009) with the permission of the World Bank.

[6] It would be maximal at exactly 50% of the maximum level if the growth phase was a perfect logistic curve.

representations (**Figure 4** bottom panel). The practical determination of the development phases is discussed below in **section 4.3.5**.

Figure 4: Idealized aggregated fisheries development model



Note: Top left: Trends in landings and growth rates (modified from Grainger and Garcia 1996). By courtesy of FAO. Top right: phase graph. The zero-growth line relates only to the rate of increase (right vertical axis). Reproduced Bottom: same representations with environmental and other noises. Modified from Garcia 2009).

2. Relation between the development cycle and the state of resources

In as much as resources evolve under the growing pressure of a developing fishery, there is an obvious connection between the fisheries development model used here and the stock surplus production model used for stock assessment. Both use landings data as a key variable and both assume a sigmoid function. The fishery development cycle assumes that the fisheries output (landings) are a sigmoid function of time and that the rate of growth is maximal around the inflexion point of the sigmoid (**Figure 4** top left). It also assumes that as the output increases, the underlying biomass decreases. The surplus stock production model for a single-species stock also assumes that the stock biomass grows towards the carrying capacity of the natural system following a sigmoid function and that stock productivity is maximal at the inflexion point. When exploited, such a system sees also the underlying biomass reduced when catches are increased, equilibrium catches are equal to natural productivity, and the maximum possible long term yield (i.e. the Maximum Sustainable Yield, MSY) is equivalent to the maximum natural stock productivity.

Annex 2 addresses briefly the intrinsic problems of that approach, particularly but not only with multispecies, multi-fleet fisheries. In a nutshell, in practice: (1) the fishing pressure does not develop in an homogenous or continuous fashion as assumed in the production model; (2) the composition of the resource targeted by a set of fisheries changes with time and does not react to fishing exactly as predicted in the case of a single-species homogenous stock confronted with an homogenous fleet (see **Annex 1 Figure** 2); and (3) other drivers will distort the apparent stock response, including climatic ones (Klyashtorin 2001). These and other problems have generated a widespread and long-standing debate on the usefulness of surplus production models in general for resources assessment (Larkin 1972; Mace 2001).

Nonetheless, considering the scarcity of information on age or length structures of Mediterranean landings, and the significant difficulty of dealing with complex multispecies multi-gear fisheries of artisanal of semi-industrial nature, the surplus production model is still often used for assessing the state of the resources at various levels, from a fishery to a region.

In order to broaden the analysis beyond the few target species presently covered by the GFCM working groups (e.g. anchovy, sardine, hake, red mullet, seabreams, shrimps), attempts have been made to use trends in catch data alone (Caddy and Garcia 1982; Garcia 1984; Grainger and Garcia 1996; Caddy and Garibaldi 2000, Garibaldi and Caddy 2004; Garcia 2009) to infer about the state of the resources. More recently, fisheries impacts were also analysed using the mean trophic level (TL) in reported landings as indicator (Pauly and Palomares 2000; Stergiou and Koulouris 2000) and this approach is not without its own problems (Caddy et al 1998; Essington et all 2006; Branch et al. 2010).

The empirical fishery development model is simply used in this study as an instrument to describe, in a qualitative and synoptic manner, the different fishery development cycles in an area, looking for patterns to compare. It is not used to assess directly the state of the resources, to calculate MSY or make forecasts. However, unless resources have been affected by very long natural cycles of 50 years or more, it should be obvious that in hind cast: (1) when the development was still low, the resource mix must have been relatively abundant; (2) when the development increased rapidly, the resource mix must have declined in some fashion; and (3) when the fisheries production reached an apparent asymptote for many years, without any apparent constraint on the sector expansion, it must be because the resource is at the limit of its productivity under the prevailing ecological and socio-economic conditions. As a consequence, even though the analysis does not assess directly the state of the resources, it cannot avoid sending a message on the likely state in which they may be, considering their empirical historical development. More details on this issue are available in the discussion (**section 6.4**).

The main assumption made in analysing FAO landings trends against the fisheries development cycle is that are that the long-term evolution of landings (over the 58 years of data available) reflects mainly the impact of fishing. This implies that: (i) there has been no significant catch-constraining management measures; (ii) changes in discard rates and improvement in species identification of landings have not been sufficient to distort the long-term relation between fishing and landings; and (iii) environmental factors have not so gravely distorted the patters as to render them misleading. These considerations will be further elaborated in **section 6.2.**

Under this assumptions, the average of the maximum catches in a long-enough time series reflecting a significant fisheries development process, may be taken as reflecting an empirical long-term resource potential of the area (long-term potential yield or Long-Term Maximum Average Yield, LTMAY *sensu* Mace 2001) and the ratio between current catches and LTMAY may be taken as a proxy indicator of the degree of development or depletion. The general steep increase in Mediterranean, sub-regional and national landings from the 1960s to the 1980s are taken to reflect the development of fishing capacity during the intense global period of industrial development that followed World War II (Garcia and Newton 1997).

Contrary to the conventional surplus production model, however, the parameters of the fisheries development model, i.e. its precise shape, the timing of the critical bending points, and the slopes of the various sections, are not precisely determined and, therefore, the trajectories cannot be precisely forecast[7].

[7] But Marchetti (1987) used the logistical (S-shaped) left part of the cycle to calculate its parameters and forecast its development and demise

3. Data processing and indicators

The data available in the Fishstat datasets were filtered using the filters defined in **section 3.2**, to extract the taxonomic and geographic components needed for this analysis. The extracted datasets were "cleaned" to eliminate alphanumeric characters, replacing them with zeros. All landings values are expressed in metric tonnes. The landings values below 0.5 tonnes have been ignored.

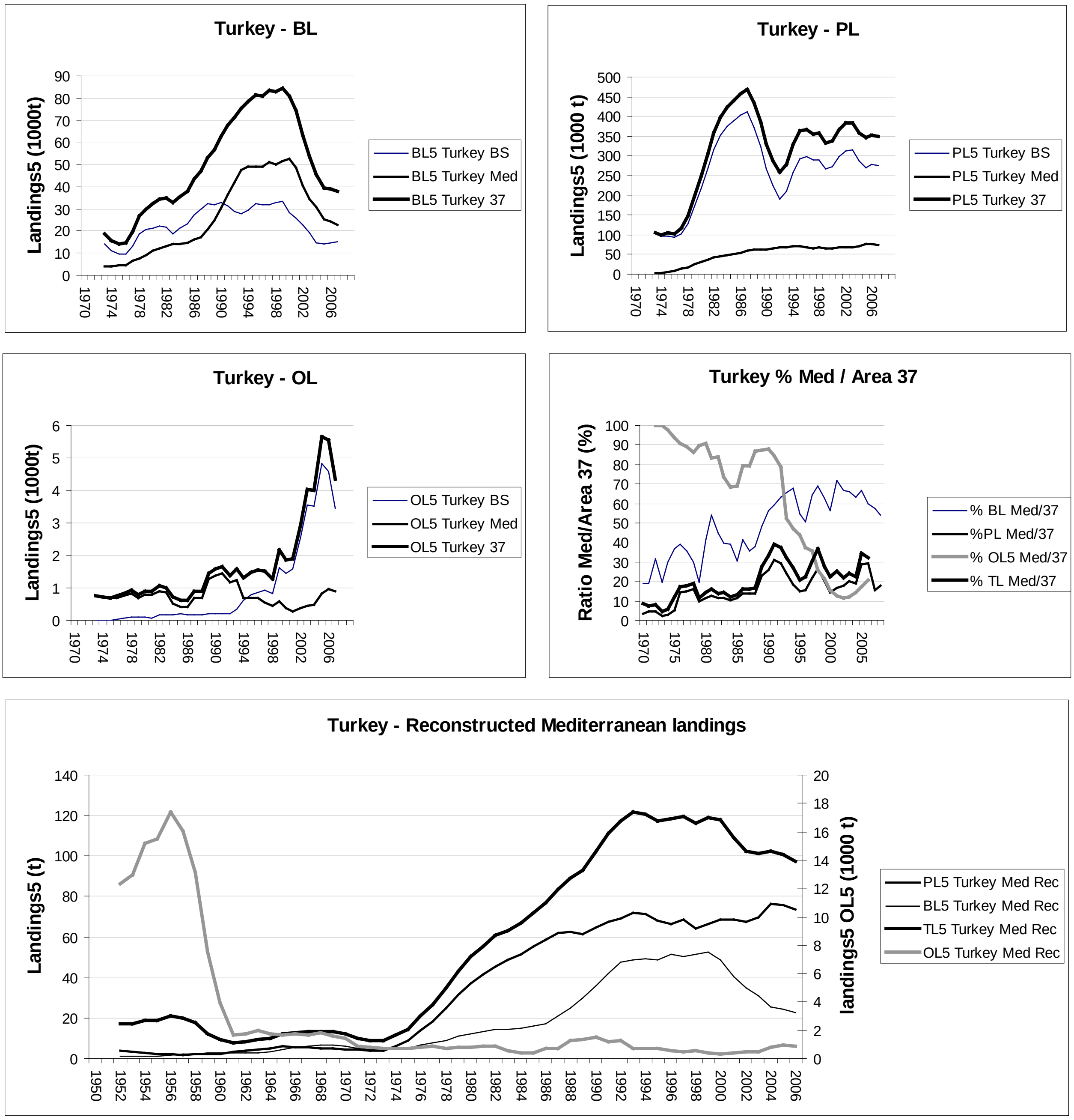
3.1. The case of Turkey

The analyses of trends by countries are performed using the longer Area 37 data set for maximum contrast. Most coastal countries of the Mediterranean fish exclusively in that sea except Turkey which exploits also the Mediterranean (in the Aegean, Levant and Marmara sub-areas) and the Black Sea. The Mediterranean and the Black Sea are two different ecosystems with different environmental, socio-economic and political histories, weakly connected through the narrow Bosphorus straight and limited exchange in small pelagic or coastal bottom fish. As a consequence, in order to have a Turkish data set as comparable as possible with that of the other Mediterranean countries, the landings of this country coming exclusively from the Mediterranean during the period 1950-2008 have been tentatively reconstructed as follows. The 1970-2008 trends of the GFCM database by sub-area show that the main development of Turkish fisheries started during the early 1970s. Landings coming from the Mediterranean before that period were limited. It was therefore assumed that the proportion of the total Turkish landings in Area 37 coming from the Mediterranean during 1950-1970 was the same as the one that can be calculated from the GFCM data for the first 5 years available (1972-1976 in the smoothed data series). This simple procedure should not create any major problem for the present analysis and it could be reconsidered if more historical information on the Turkish sector development becomes available.

Figure 5 shows the trends in the BL, PL and OL categories of landings based on the data available in the GFCM database 1970-2008, smoothed on 5 values. The Mediterranean (including the Sea of Marmara) and Black Sea landings are shown separately. It is clear that the trends are very different and that, in order to be coherent with the other analyses by country, it is preferable to use only the data from the Mediterranean. The percentage of the landings (BL, PL, OL and TL) of the Area 37 coming from the Mediterranean *sensu stricto* was calculated for each category for 1970-1974. The percentages of all categories except Other Fish have progressively increased with time (**Figure 5**, **Middle left**). The latter has decreased very conspicuously from 90-100% in the early 1970s to 10-20% in the late 2000s reflecting an improvement on reporting and most probably on the market. The percentages calculated for 1972-1976[8] (smoothed data) were applied to the Area 37 data for 1950-1970 to generate a corrected time series for Turkey and for the Mediterranean resources categories Bottom Fish (BL), Pelagic Fish (PL), Other Fish OL) and Total Fish (TL) (**Figure 5, Bottom**). The same procedure was also applied to Sharks & Rays (SRL), Shrimps & Prawns (SPL), Lobsters (LL) and Cephalopods (CL) and the results are shown in the development cycles analysis (**section 4.1.1-Mediterranean-wide temporal trends**).

[8] Values obtained: BL (29.5%); PL (6.5%), OL (96.5%)

Figure 5: Turkish landings



Source: Fishstat GFCM database 1970-2008

Note: Top: Bottom Fish (BL) and Pelagic Fish (PL). Middle: Other Fish (OL) and % of Mediterranean landings in Area 37. Bottom: Reconstructed time series for 1950-2009. Note: the OL5 landings are on a different scale.

3.2. Landings and Rates of Increase

In order to reduce high frequency natural and sampling variability, and to buffer the delayed responses of the resources mix to changes in fishing or the environment, the landing time series (e.g. TL, PL, BL, and OL) were smoothed by a simple running average on five years[9] (TL5, PL5, BL5 and OL5).

For each of the smoothed time series of landings (L5) the annual rate of increase (ROI) was calculated as:

ROI (t) = [(L5(t) – L5(t-1))/L5(t-1)]*100

3.3. Long-Term Maximum Average Yield (LTMAY)

For each time series, the long-term Maximum Average Yield (LTMAY) defined as *the maximum average yield obtained by applying a specific harvesting strategy to a fluctuating resource* (Mace 2001: 5) was calculated as the average of the smoothed landings in the 5 contiguous years corresponding to the period during which the smoothed landings were highest and the growth rates crossed the zero-growth line. The smoothing highlights the trends and facilitates the determination of the maximum. It also limits the influence of spikes on the definition of the "maximum".

As mentioned earlier (cf. **section 4.2**), the empirical LTMAY is not considered as the conventional theoretical Maximum Sustainable Yield (MSY). Depending on long-term environmentally- driven cycles as well as on harvest strategies (and markets opportunities), it is at best a transient proxy towards it. As the individual LTMAYs of single stocks -within a multispecies resource category or within a region- are not achieved simultaneously, the overall LTMAY is de facto an underestimate of the theoretical maximum assuming all resources could be optimized simultaneously. In the concept of Home Area, in addition, the LTMAY will increase with time together with the extension of the Home Area (e.g. into deeper waters).

In cases where the patterns shows a long period (e.g. a decade or two) of yield oscillating at high level without trend, the whole period is used to calculate the LTMAY.

In cases of erratic time series –as is often the case with very small fishing states- the yields of the whole period are averaged to represent the LTMAY.

3.4. Relative landings (RL5)

All landing time series were smoothed yearly landings (L5) in a time series were normalized using the LTMAY of that series as the base, as follows:

Relative landing = **RL5(t) = [L5(t)/LTMAY]*100**

The RL5(t) time series have then been analysed to determine the different phases of the historical development cycle as follows selecting arbitrarily 90% as the RL5 limit value for the phases:

- Developing: when RL5 increases and is below 90% of LTMAY
- Mature: When RL5 is >90% of LTMAY
- Senescent: when RL5 decreases and falls below 90% of LTMAY again.

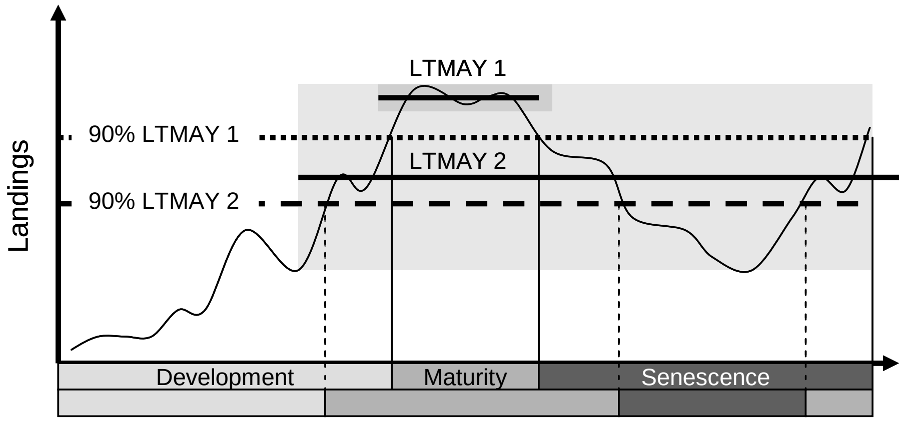
It is clear that changing this percentage to a lower or higher level will increase or decrease the length of the period of maturity at the expense of those of development and senescence. In addition, when the maturity period is protracted, it is usually affected by interannual and medium-term oscillations. The relative length of the phases and indeed the entire diagnostic about one time series depends on the signal/noise ratio

[9] The number of years on which to calculate the average was chosen as a compromise evidencing the trends clearly enough and reducing spikes while not reducing too much the length of the time series.

adopted explicitly or implicitly. As shown in **Figure 6** below, the identification of development phases will depend on what type of oscillation is considered as a "noise" around the LTMAY and averaged.

Raising the ratio, i.e. considering only the smaller fluctuations as "noise" (example LTMAY 1 on the figure), lengthens the development phase, this may show numerous oscillations as successions of mini-phases of maturity and senescence. Lowering it, i.e. considering lower frequency fluctuations also as environmental "noise" and averaging them (example of LTMAY 2 on the figure) leads include more and more important fluctuations in the maturity stage, lengthening it, and leading therefore to more optimistic diagnoses, with shorter development phases and longer sustainable maturity phases, characterizing a more rapid but more sustainable development.

Figure 6: Relation between the definition of LTMAY and the development phases



In the cases where the landings are rising during the entire observed period, the LTMAY is obviously not available. No extrapolation of the data (e.g. using the polynomial trend line) can be attempted. Instead, the entire time series was coded as "Developing" and coloured in green.

In the cases of important landings (tens of thousands of tonnes) showing oscillations without trend since 1950, the fisheries were considered as "mature" for the whole period and coloured in yellow.

3.5. Synoptic representations

In Excel, each annual cell was manually colour-coded on the basis of the development phase it was part of: green for Development, yellow for Maturity and red for Senescence. The colours have been chosen in relation to the standard convention for signalling degrees of danger in the framework of the precautionary approach. This provides a visual qualitative and standardized description of the cycles allowing the comparisons of trajectories between resource categories and between sub-areas (see for example **Figure 18**). In order to have an even more synoptic representation of the time trends of resources in Home areas, sub-areas and the Mediterranean, the yearly percentages of all sub-areas or countries in each development phase were calculated see for example **Figure 18**, bottom)**.** Whether or not such overall percentages should be weighted or not was carefully considered. On the one hand, weighting each percentage by the importance of the underlying resource (e.g. using the LTMAY) would obviously give a statistically better indicator of the overall situation. However, the differences between resources categories and areas are not random and are important. The weighting would allow the most important resources or sub-areas to "impose" their pattern to the total, potentially the really relevant information. For example, if 2 major areas were in deep senescence (or in development) while 5 minor ones were in an early development stage (or depleted), the weighted % would say that, overall the Mediterranean is in deep senescence (or developing) hiding the real (better or worse) situation. Considering that this report was to be considered by decision-makers having to make locally relevant decisions and not just global statements, it was decided not to use any weighting. In any case, the Excel database is made available with the report and the weighting could be easily introduced at a later stage if so desired.

V. Results

In the following sections, some general trends of the selected landings will be presented, at both Mediterranean and sub-area levels to show their relative importance and compare their general evolution. Then, the development cycles will be described, identifying the main types emerging from the data. The cycles will then be analysed, drilling down from the Mediterranean to the national (Home Area) levels based on the variant of the aggregated fishery development model presented on **Figure 2** (bottom panel). Brief diagnoses on the state of the fisheries development will be made before summarizing the results in synoptic qualitative presentation, offering an opportunity to zoom out again to sub-regional and Mediterranean-wide visions of fisheries development, by country and by resource category.

1. Resources trend analysis

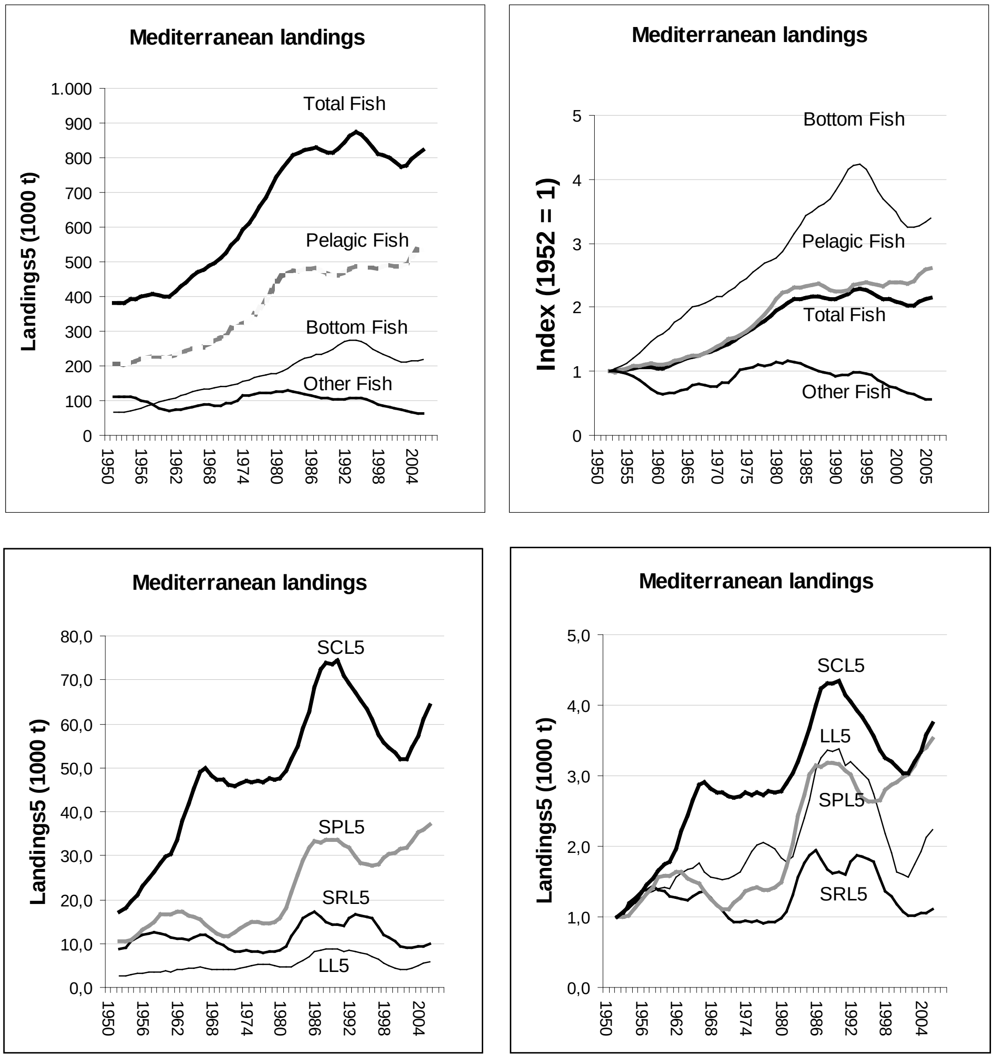
1.1. Mediterranean-wide trends (1950-2008)

The analysis is performed on the Area 37 database, in which the Turkish landings have been corrected as described in **section 4.3.1**. Regarding the main selected categories, **Figure 7** (top panels) shows that small pelagic fish landings grew exponentially from 1950 to 1980 and have oscillated since then around 500,000 tones. Bottom fish landings have continued to increase until 1994 (over 295,000 tonnes) when they started to decrease steadily. The Other Fish landings (i.e. the fish tagged in Fishstat as "Marine fish not identified") oscillated around 100,000 tonnes until the mid 1980s and then started decreasing indicating a progressive improvement in the identification and reported statistics and, probably, in the market as other species abundance decreased. As a result, Total Landings rose until the early 1980s and oscillated since then around 800,000 tonnes. In relative terms, the Bottom fish landings growth has been the most impressive (cf. **Figure 7** top right), perhaps in part because it benefited more from the transfer from the Other Fish category as identification improved.

Regarding the other categories of landings (**Figure 7**, bottom panels), Squids, Cuttlefish and Octopus (SCL5) as well as Shrimps and Prawns (SPL5) are still increasing with strong medium-term oscillations which may blur their possible levelling off in the last decade. Sharks and Rays have gone through 2 strong oscillations lasting about 2 decades before returning to their 1952 levels, indicating either a strong environmental oscillation or two periods of development-maturity-senescence separated by a period of rest and recovery. The evidences of chronic degradation of shark resources and collapse of all the directed shark fisheries in the 1960s (cf. **section 6.4.2** - Validation of the conclusions) point towards the second interpretation, i.e. repeated overfishing. The Lobsters shown an impressive three-fold development in 40 years followed by 2 decades of senescence. Altogether, cephalopods and shrimps are still producing more, with oscillations, as expected for short-lived prey species. On the contrary, the vulnerable Sharks and Rays seem to have been exploited in an unsustainable way. Altogether also, the high value species (bottom fish, lobsters, shrimps and cephalopods) have shown the highest relative increases in landings but also -for Bottom Fish and lobsters) marked declines for the last 20 years.

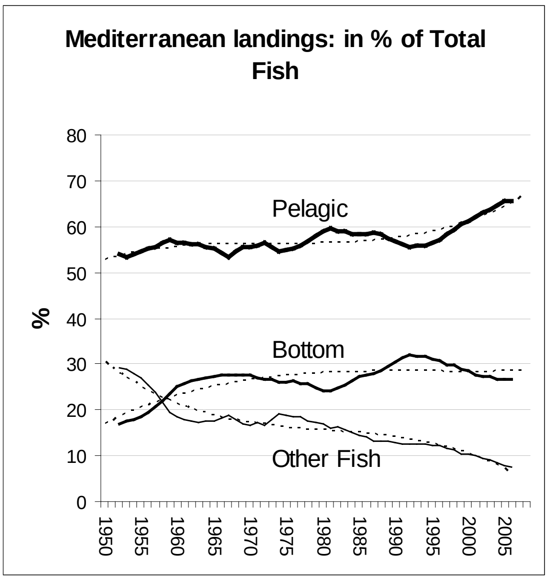
Figure 8 shows that on the longer term, the percentage of pelagic fish (PL) and bottom fish (BL) in the total landings has increased with time at the expense of the percentage of unidentified fish (OL) which decreased regularly from close to 30% in the early years to about 7.5% in the latest ones, stressing again the improvement in identification, reporting and markets for secondary target species.

Figure 7: Mediterranean-wide trends in the selected landing categories



Note: Left panels: tonnage. Right panels: relative index taking 1952 as the base.

Figure 8: Trends in landings composition (in % of TL) of the three main taxonomic categories: Bottom Fish (BL), Pelagic Fish (PL) and Other Fish (OL)



1.2. Sub-regional trends (1970-2008)

In this section, the trends in each resource category are examined in the different GFCM sub-areas (**Figure 9 - Figure 12**).

The Total Fish landings of the Mediterranean as a whole have increased until the end of the 1980s and have been oscillating since then around 800,000 tonnes (**Figure 9**). The long-term trends are easier to see in the lower panel which shows only the trend lines. There are clear differences between sub-areas. The landings decreased in the Sardinia area from 1970 to 2000 and may be recovering. In the Gulf of Lion they have been rather stable with a slight maximum in the mid-1990s. In the Adriatic they peaked in the late 1970s and decreased since then reaching their lowest values during the last decade. In the Ionian and Aegean areas, they peaked in the mid-to-late 1990s and decreased during the last decade. In the easternmost areas, Levant and Marmara, the landings are still raising. While these trends is resources mixtures are not easy to interpret and reflect probably mainly the changes in small pelagics in the most productive areas, they indicate that the senescent phase started earlier in the West than in the East, perhaps logically following trends in economic development. A notable exception is the Balearic area which is apparently still slightly growing. These trends might be better understood when examining separately the trends by landing category and by country in each sub-area.

The small Pelagic Fish landings of the Mediterranean are still slowly increasing, at a rate much slower than in the 1970s (**Figure 10**) and have reached about 550,000 tonnes. The major contributions come from Balearic and Adriatic areas. The landings follow the same general trend in the Balearic area where they are approaching 200,000 tonnes, the Ionian with about 75,000 tonnes and the Marmara with around 50,000 tonnes. In the other areas, the landings peaked and then declined since the 1970s in the Sardina area, the early 1980s in the Adriatic, the mid 1980s in the Gulf of Lion, and the mid 1990s in the Aegean. Here also, with the exception of the Balearic, there seem to be an eastward trend in the time at which the fisheries reached an "asymptote".

The Bottom Fish landings of the Mediterranean, as expected for a much higher- value group of species have peaked earlier than the pelagics, in the mid-1990s with about 275,000 tonnes (**Figure 11**). The major contributions come from the Ionian, Aegean, Balearic and Levant areas. The landings are still growing in the Balearic (close to 40,000 tonnes) where they seem to be recovering from their decrease in the 1980s. On the contrary, they decreased in Sardinia area since 1970, Gulf of Lion since the mid-1980s, Ionian since the early 1990s, Aegean since the mid-1990s, in Levant and Marmara since the late 1990s. Contrary to the Pelagic Fish, but logically considering their higher commercial value, the BL landings decrease in most areas and in the Mediterranean as a whole during the last 2 decades. In most if not all these areas, there are no management measures to curtail catches, no limit to what the rich regional market can absorb and no real impediment to technological progress even though most fisheries remained artisanal or semi-industrial. One logical conclusion is that, to a variable extent in the different regions, the blocking factor is probably the resource itself.

The confirmation should come from observation of the landed sizes. This information was not available to the author but his own experience in the main markets of Rome during the last 30 years indicate that the top species have become very scarce and large sizes have been unavailable for the last decade except perhaps in the very expensive restaurants of the Italian capital. In that lapse of time, cultured seabreams, sea basses, turbots and shrimps, as well as wild shrimps from Argentina have largely replaced the wild local ones, including in most low to medium-class restaurants.

The Other Fish landings of the Mediterranean (**Figure 12**) represent a contribution of about 60,000 tonnes in recent times, well below the peak of about 100,000 tonnes in the late 1970s and early 1980s. Being a mixture the composition of which has probably varied with time as market niches were opened and identification improved, they cannot tell much about the state of the Mediterranean resources. The landings decreased in all areas. It should be noted, however, that the deficit in Other Fish landings could come from:

- A progressive depletion of these resources that bear the same pressure as the other coastal resources and are in many cases secondary if not primary targets.

- A transfer from OL to BL as they are better identified, including through small sizes being sorted out and sold at a good price instead of mixed in a "soup" category.
- Most probably a bit of the two reasons.

In the first case, the faster decline should be a concern in relation to OL species. In the second, the decline in BL may have been partly masked by the transfer of OL resources to the BL category and this should raise concern regarding the state of the BL species which might be more serious than it seems considering their apparent trend.

Overview and conclusions

The landings patterns of the main selected categories (PL, BL and OL) are superimposed, for each GFCM sub-area on **Plate 1**. The figures show that since 1970, the landings of the selected resources types have:

- Remained relatively stable for 2-3 decades at least in the Balearic islands and the Gulf of Lion, with strong oscillations in the second;
- Decreased continuously in the Sardinia sub-area with a slow recovery in the last decade;
- Increased continuously and significantly for many decades in the Ionian and Levant sub-areas with strong fluctuations.
- The Aegean and Marmara area have shown significant increases for decades followed by significant decreases in the last one or two decades.

It is interesting to note at this stage that the western areas (Balearic and Gulf of Lion) areas seem to have rather stabilized their production many decades ago (long-term maturity) while central areas (Adriatic and Sardinia) have decreased production levels and eastern areas (with the exception of Bottom Fish in the Sea of Marmara) have been increasing production.

Differences between sub-areas emerge on the relative levels of landings in Pelagic Fish and Bottom Fish, that could indicate differences in ecology or/and fisheries development strategies. The Mediterranean Sea presents known regional gradients in ecological characteristics from its connection with the Atlantic through Gibraltar straight to its easternmost shores of the Middle East countries (Bas Pereid 2002). The west is supposed to have a higher primary productivity than the East, with the anomaly of the Adriatic, in the centre, strongly enriched by the Po river. Socio-economic differences exist also between the North and South coast of the Sea with higher development levels on the European side.

The ratio between bottom and pelagic fish landings is interesting. It could reflect the different interests of the various countries for the different species. However, it could also reflect ecological differences, e.g. related to the presence-absence of upwellings or river outflows and pollution (for small pelagic fishes) or shelf area (for bottom fishes).

Figure 13 (left) illustrates the wide range of ratios that can be observed within the Mediterranean as well as the fact that this range has significantly decreased during the last three and half decades.

The phenomenon is better seen on **Figure 13** (right) which shows that there is a growing trend in the BL5/PL5 ratio from the Straight of Gibraltar (Balearic area) to the Turkish coast (Levant area) with two low outliers with relatively high pelagic landings: (1) the Adriatic, polluted by the Po River and extremely rich in small pelagic species; and (2) the small Sea of Marmara that connect the Mediterranean with the Black Sea. It seems therefore that the landing levels follow the ecological trend with larger pelagic resources relative to bottom ones where the primary productivity is higher, i.e. in the West and in the Adriatic.

Figure 13 (left) shows also that the difference between the West and the East Mediterranean was more clearly marked in the 1970s than in the 2000s. Indeed, in the West (Balearic and Gulf of Lion) the ratio remained stable while it decreased in the central and eastern sub-areas. This indicates that the relatively larger expansion of the Bottom Fish landings compared to Pelagic Fish landings that has been observed in the Mediterranean as a whole (**Figure 7**, top-left panel) is largely due to what has happened in the central and above all in the eastern sub-areas. In the Adriatic and the Marmara, the proportions have remained practically unchanged.

Figure 9: Top: Trends in Total Fish Landings (TL5) in the GFCM sub-areas. Bottom: Trend lines (3rd order Polynomial)

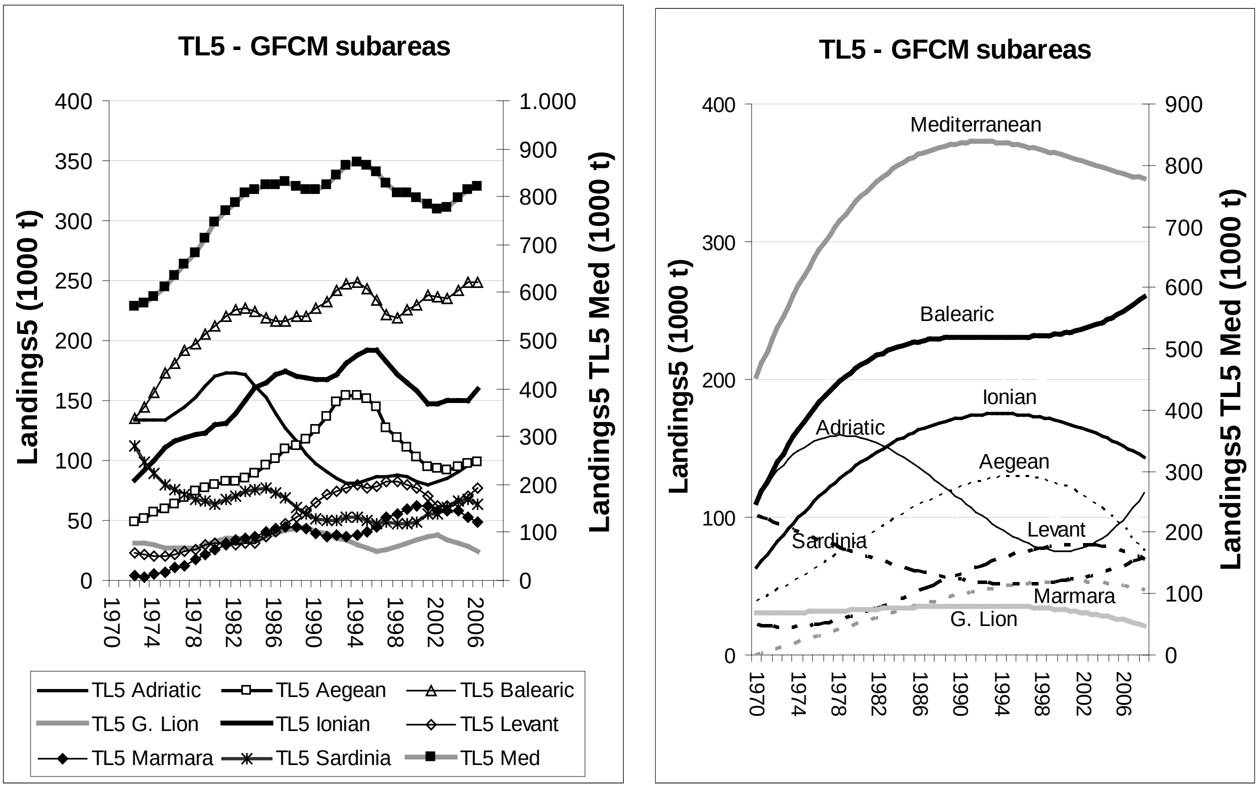


Figure 10: Top: Trends in Pelagic Fish Landings (PL5) in the GFCM sub-areas. Bottom: Trend lines. (3rd order Polynomial)

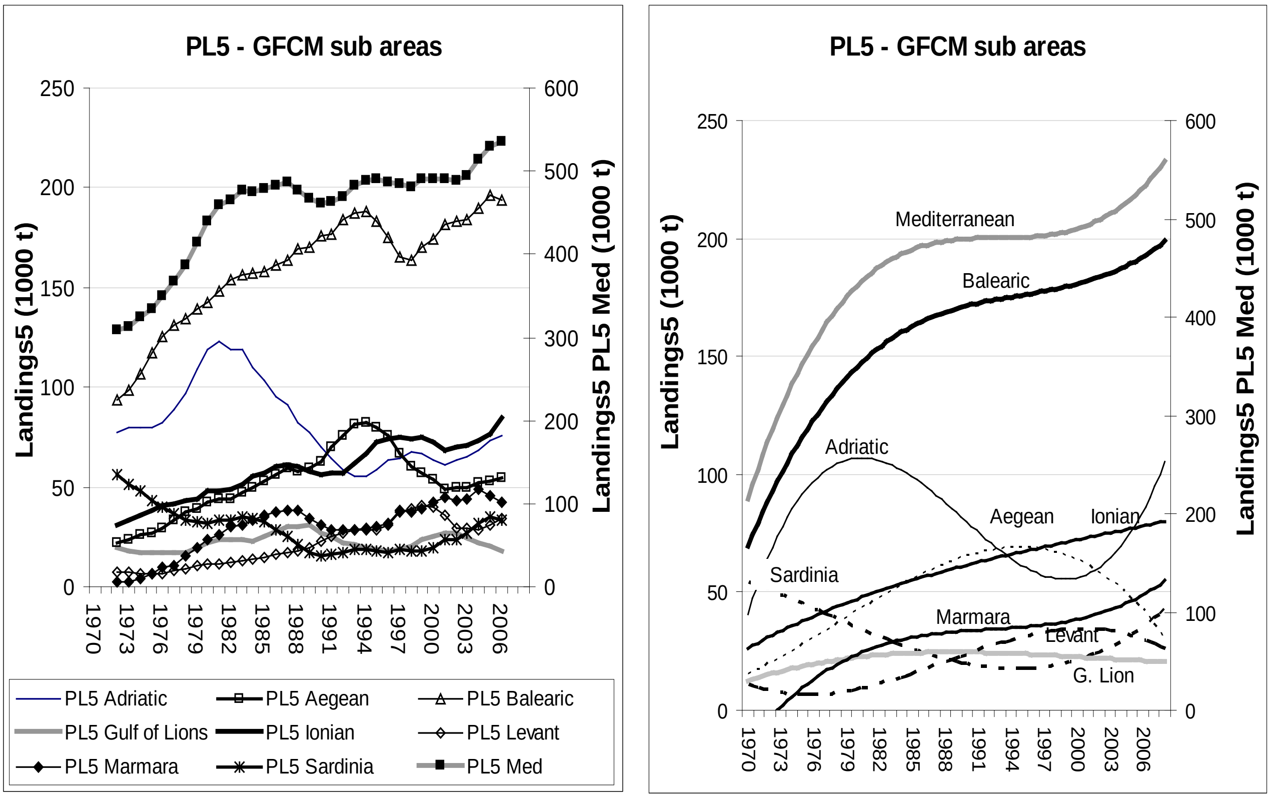


Figure 11: Top: Trends in Bottom Fish Landings (BL5) in the GFCM sub-areas. Bottom: Trend lines. (3rd order Polynomial)

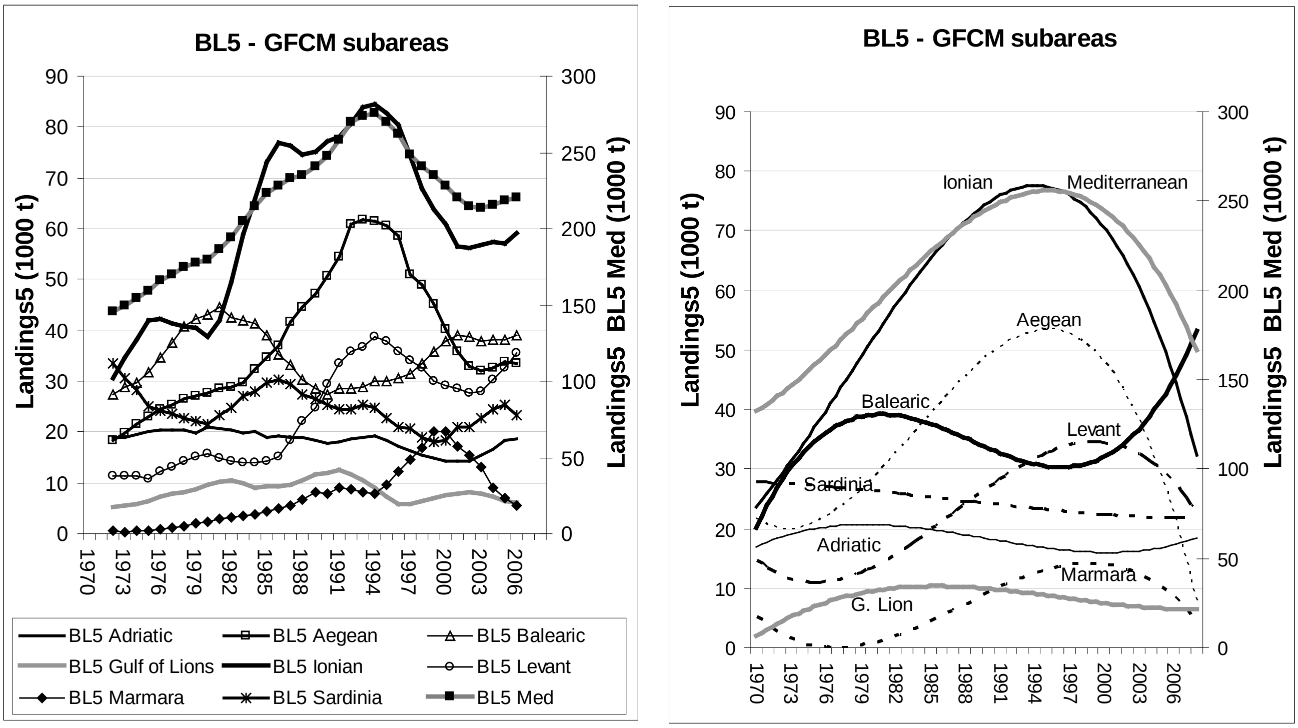


Figure 12: Top: Trends in Other Fish landings (OL5) in the GFCM sub-areas. Bottom: Trend lines. (3rd order Polynomial)

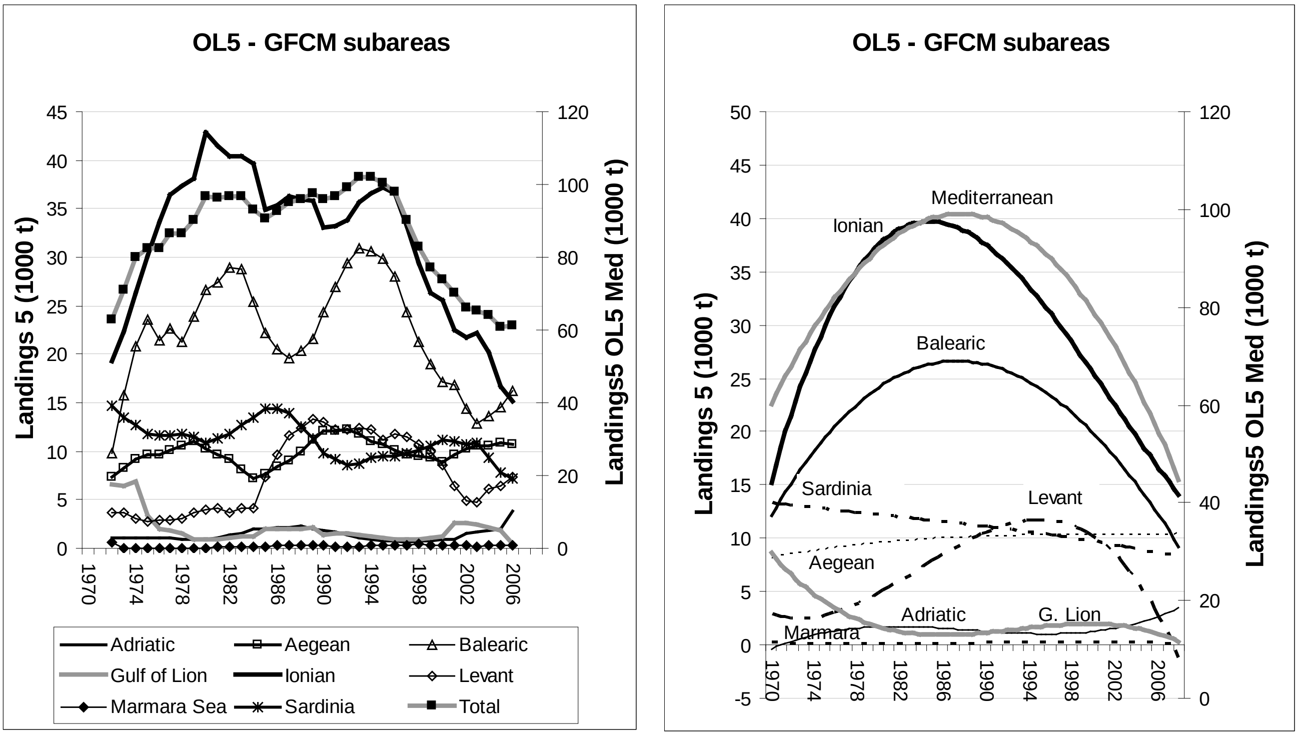
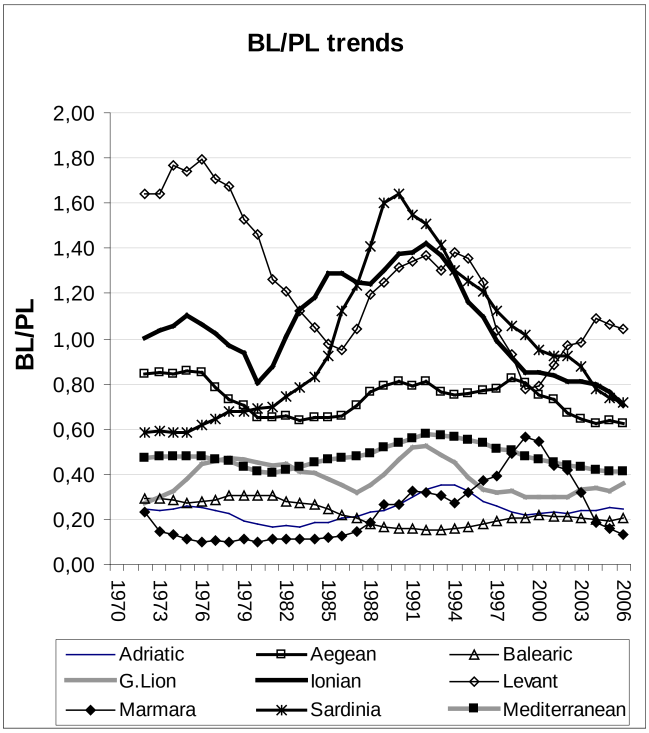
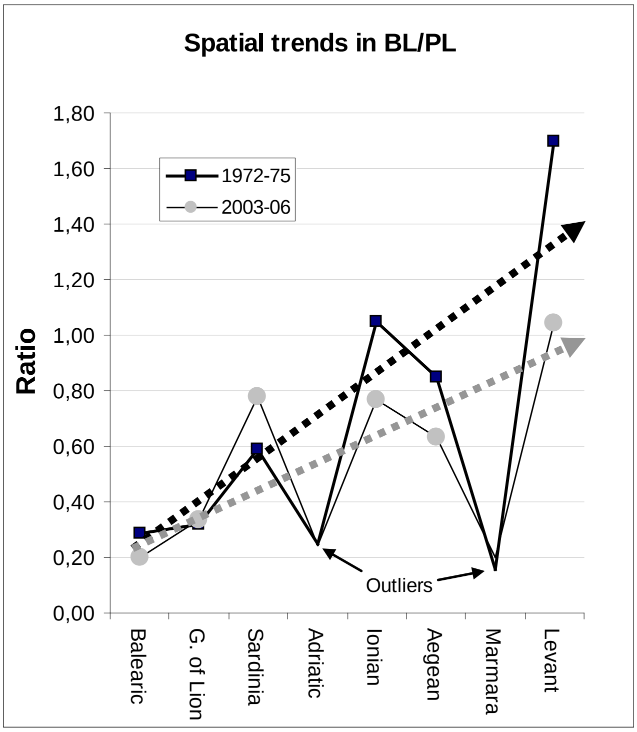


Figure 13: Time (left) and space (right) trends in the BL/PL ratio in GFCM sub-areas, 1970-2008





2. Development cycles

The landing data by resource categories, aggregated for the Mediterranean as a whole, or at regional or national level (see **Plates 2 to 12**) support clearly the description of fisheries development elaborated in **section 4.1** as a sequence of fast growth phases separated by short periods of stabilization (or decline) where the growth rate is nil or negative. The transition from exponential growth (Development) to the long-term landings asymptote (Maturity) and from it to Senescence is clear in a very large number of patterns. In some others, usually because the early development phases are missing, the observed development pattern cannot be easily interpreted (e.g. when it is Undetermined).

The medium-term fluctuations (particularly in growth rates where they are amplified) look similar to those of the general model, with "mini phases" of growth, maturity and decline and rapid transition to the next cycle, but should not be confused with them. These fluctuations could be driven by economic decisions or by the environment. As the sector tends to develop rapidly on medium-term natural fluctuations _and sometimes collapse with them_ the difference between the two possible mechanisms cannot be addressed with the data used in this report and is irrelevant in the framework of this study.

The interpretation of the cycle and its various phases is somewhat assisted by the simultaneous observation of the landings and the rates of increase as the zero-values of the latter characterize extreme landing values, i.e. asymptotic or interim maximums of production. It is important to note that the oscillatory asymptote towards which the landing curve tends may bear no relation to the conventional concept of Maximum Sustainable Yield (MSY). The reaching of an apparent asymptotic landing level, when the long term trend in growth rates is zeroing, is taken as a clear sign that the saturation level, or empirical maximum production of the underlying, area under the prevailing conditions, is being reached. It was found that the elaboration of a phase graph, correlating landings and growth rates helped in identifying the development phase, particularly in presence of strong oscillations. Many of these landing asymptotes may be transient. The long-term increasing trend in landings may result from: (i) increased fishing effort (as in a conventional production model); (ii) expansion of the area fished and hence of the underlying exploitable biomass, within the EEZ or/and in the adjacent areas as the grounds already in use become less profitable; (iii) change in fishing strategies, finding new targets ("fishing through the food webs" *sensu* Essington et al 2006") as well (iv) true ecosystem modifications under fishing pressure ("fishing down the food web" *sensu* Pauly et al

1998) or environmental change. An asymptote marks therefore one of the pragmatic maximums that the area could offer given various exploitation strategies and climate variation patterns (see **section 6.4** for a discussion of this issue). It is also accepted that, at some point, the "ultimate asymptote" will be reached when the extreme limits of the accessible area and resources will be reached and in that case, the average landings and their variability, in the absence of discards, might be closest to an empirical multi-species and multi-fishery MSY.

2.1. Typical patterns and current state of development

The smoothed data graphically represented on **Plates 2-12** and **Figure 19 to Figure 23** show the typical patterns observed at national, regional and Mediterranean level and their variability. However, their careful examination point to a number of typical patterns more or less distorted by medium-term oscillations. **Figure 14** shows some of these patterns (left column) and their schematic interpretation (right column):

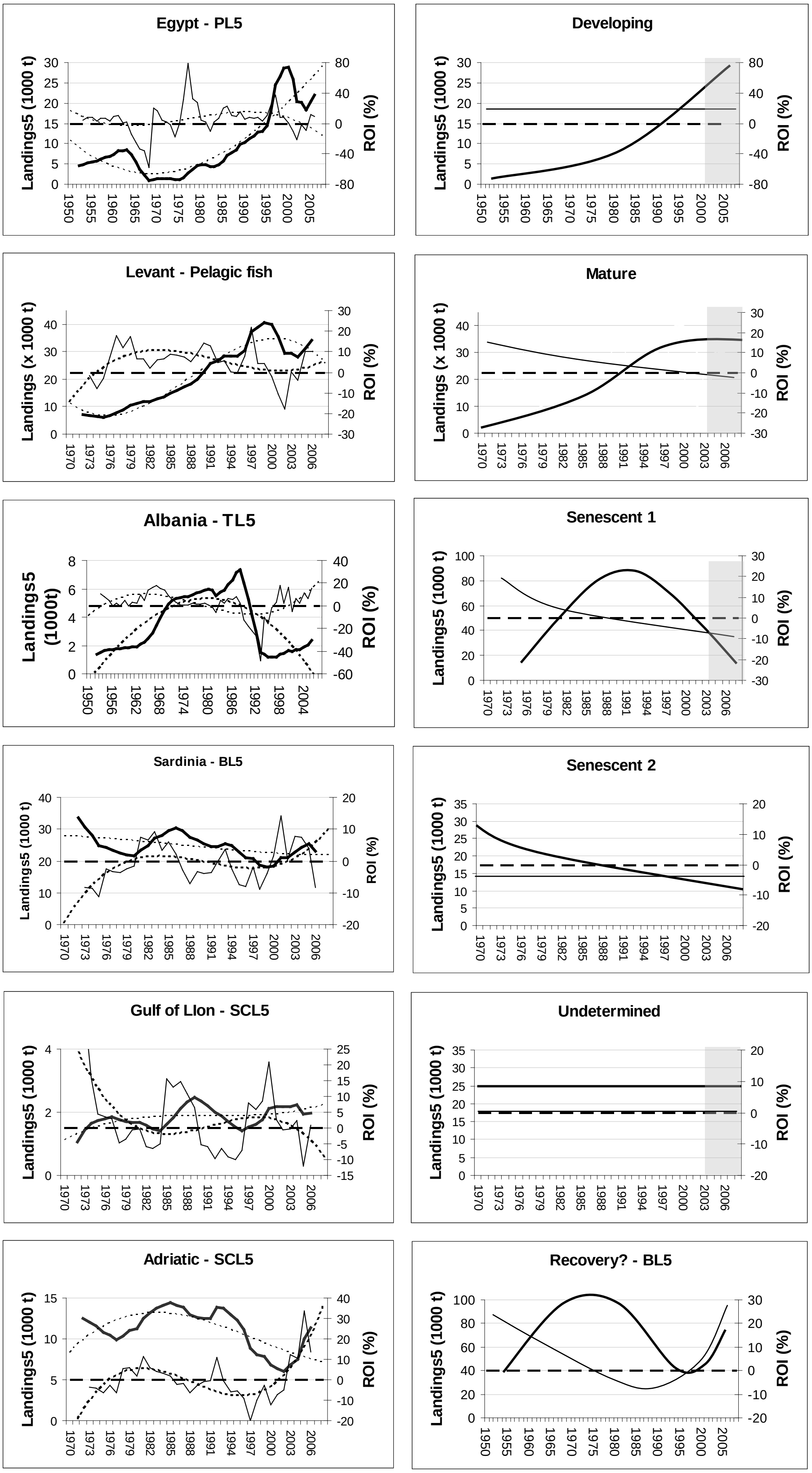
- Continuous development. The landings increase more or less regularly (linearly or exponentially) across the whole observation period. The growth rate trendline remains above zero on average even though some annual values may be negative during medium-term oscillations. The example is given by Egypt Pelagic Fish (**Figure 14**, top row);
- Full cycle: The landings have increased, with fluctuations, during one or two decades, fluctuated around some asymptote and declined during the last one or two decades. The growth rate shows a clear negative trends (despite strong osciillations) that crosses the zero-growth line when the landings stagnate. The exxample is given by Albania Pelagic Fish (**Figure 14,** third row);
- Continuous decline. The landings decrease during the entire period. An example is given by Sardinia Bottom Fish (**Figure 14**, fourth row);
- Undetermined. The landings oscillate without a clear trend during the entire period and the growth rate oscillates around the zero-growth line. In this situation it is impossible to establish at which level of development the fishery or the area is. The example is given by the Gulf of Lions cephalopods (**Figure 14**, fifth row); and
- Recovery. The term is intended to apply only when the development resumes after a full development cycle and in any case after a long period of senescence. It should not be confused with the more numerous small "recoveries" accompanying all medium-term oscillations. The example is given by the Adriatic cephalopod resources (**Figure 14**, bottom row).

The wide range of patterns observed at all level of aggregation are variations of one of these types and are affected by medium-term oscillations that may complicate the diagnosis. The elements necessary for the interpretation of such patterns are given in **section 6.4**.

2.2. Current stage of development

The "current" stage of development of an area or fishery within the 1950-2008 pattern is determined by the trend observed in the last decade (the grey areas in **Figure 14**, right column), disregarding the smaller oscillations. The titles of the graphs in that column, correspond the situation in that last decade: (1) Developing when the landings increase and the growth rate is positive: (2) Mature when the landings stagnate around some "asymptote" and the growth rate oscillates around zero; (3) Senescent when the landings decrease (since the beginning of the series or following a maturity phase) and the growth rate is negative; (4) Recovery when the recent landings are rising again following a clear period of senescence. This phase is rarely easy to confirm unless the period of senescence is long enough. (5) Undertermined. The growth rate oscillates around zero from the origin of the data. The fishery could be undeveloped, fully developed (mature) or in an transient maturity stage. The level of landings as well as additional data on the sizes landed and the reasons for "stagnation" may help resolving the uncertainty.

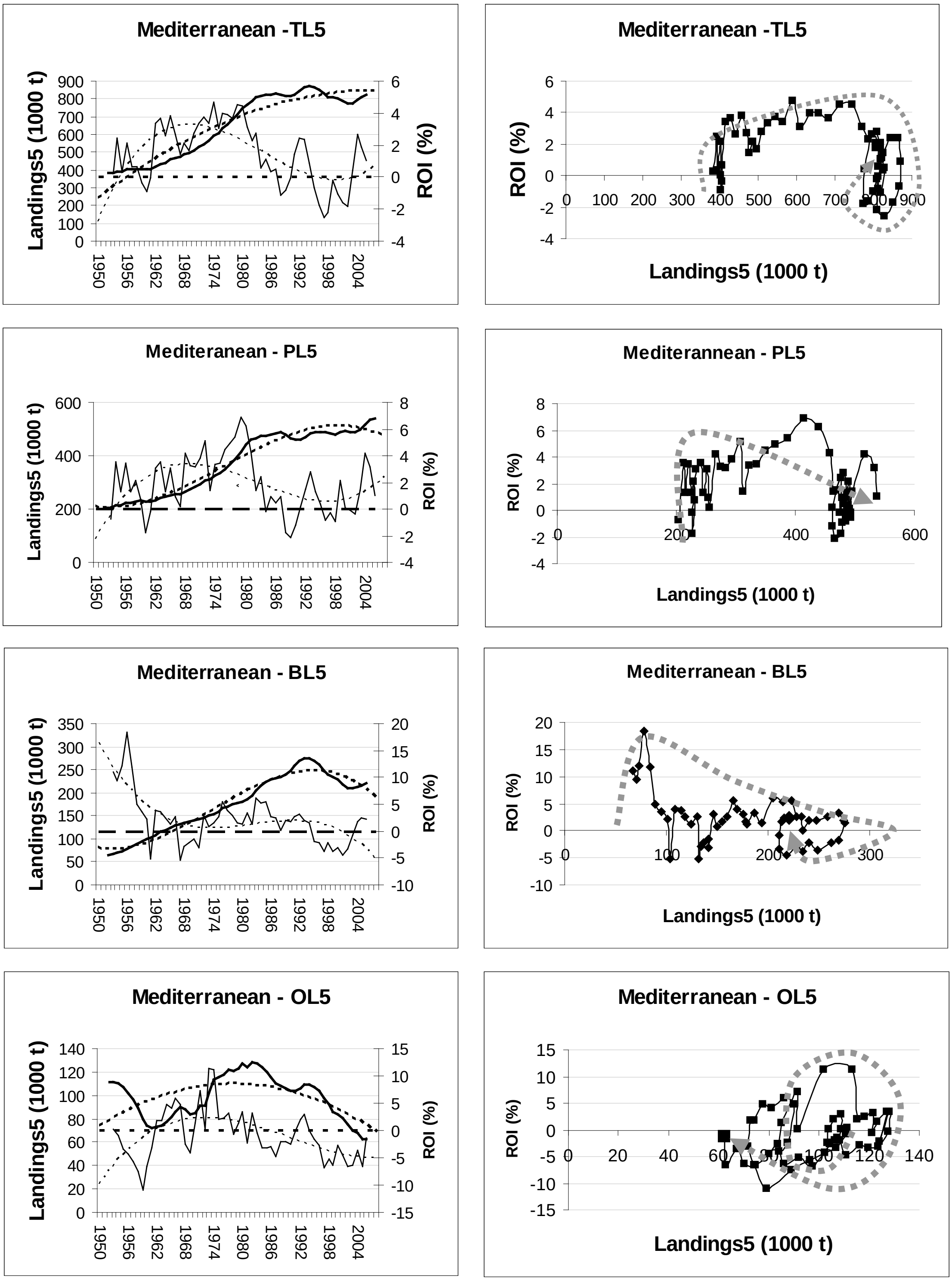
Figure 14: Typical fishery development patterns (modified from Garcia 2009). The name of the development phase applies to the last years of observation (grey area)



2.3. Mediterranean-level development cycles: 1950-2008

Using the FAO database for Area 37 (1950-2008) corrected as mentioned in **section 4.3.1** in the case of Turkey, the development cycles were examined for all the selected resource categories.

Figure 15: Mediterranean-wide landing patterns: Total Fish (TL5); Pelagic Fish (PL5); Bottom Fish (BL5) and Other Fish (OL5)



Note: Left: Landings (thick line) and Rate of increase (ROI, thin line). Trend lines (3rd polynomial, dotted lines). Right: phase graph: The sense of the trajectory is indicated by the dotted grey line. The last point (2006) is the largest square.

On **Figure 15**, the landings in the Total Fish category increased exponentially by about 100% from 1950 to 1980 and fluctuated since then around 800,000 tonnes. The phase graph (right) offers another view of that apparently simple development cycle. The following figures show that this pattern hides different ones for the two major types of resources. The Pelagic Fish, which represent indeed a dominant part of the TL category, confirms the sustained production plateau (Maturity stage) since 1980, around about 450,000 tonnes. The Bottom Fish, on the contrary, show a linear increase in landings until 1990 followed by a rapid quasi symmetrical decrease for the following 15 years. The phase graph suggest that, in the future, the fishery may stabilize around 200-250,000 tonnes. As discussed later (**section 6.2**), the absence of real impediment to landing more fish in relatively wealthy Mediterranean, and the maintenance of fishing capacity despite fleets reduction policies in the last 2 decades (in European countries), would point to overfishing as the most likely cause for this decline. The very high proportion of conventional assessments for the Mediterranean that point to overexploitation of the demersal resources would support that assumption. The landings of the Other Fish category are more difficult to interpret as there can be even more reasons for the observed evolutions. Between 1950 and 2008, oscillated between 7,5 and 15% of the Total Fish landings with a steady 50% decrease since the 1980s. This category has not been analysed beyond the Mediterranean level.

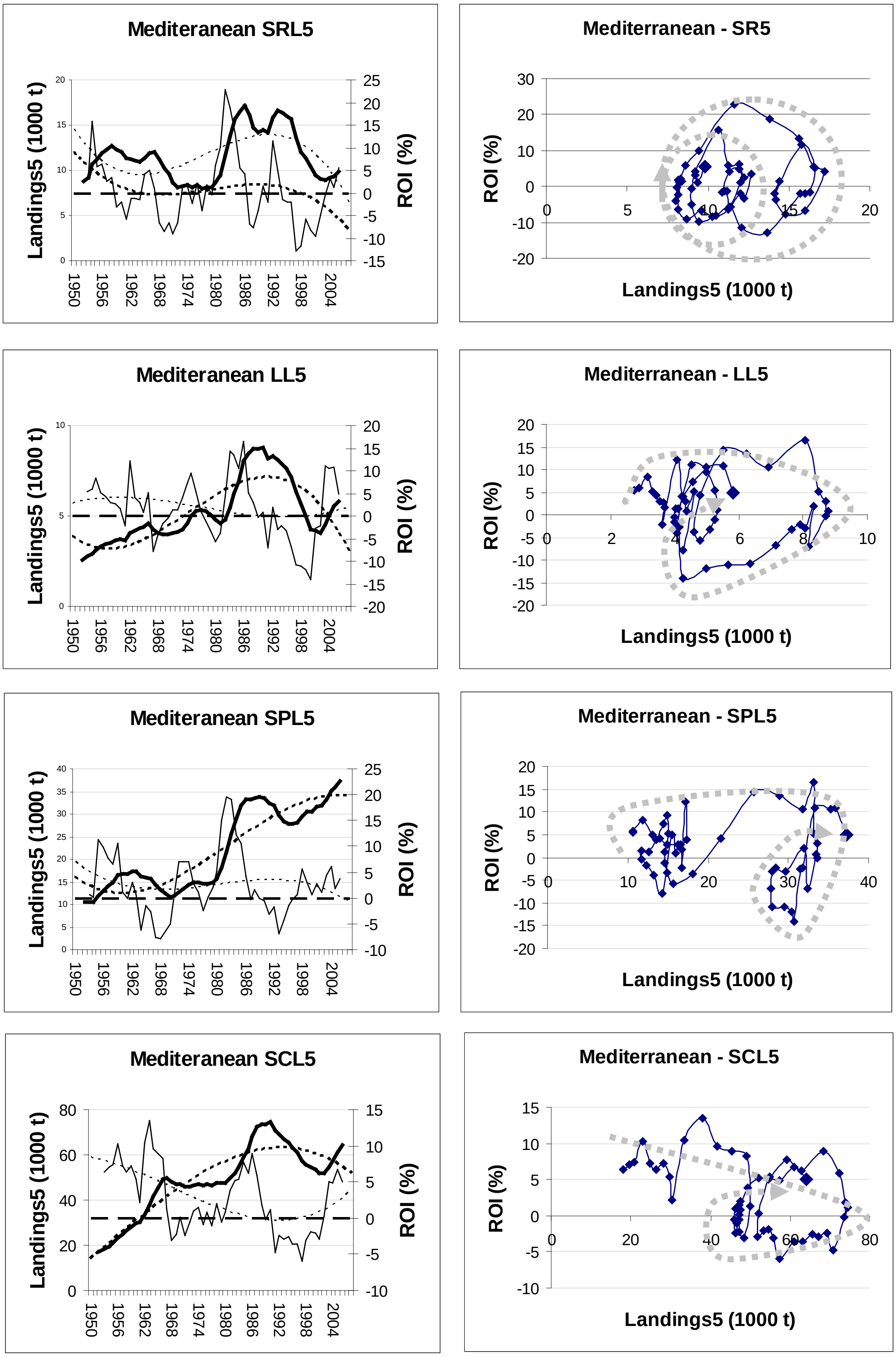
On **Figure 16**, we have represented to development cycles of the "indicator" species. Sharks & Rays contain many species usually considered particularly susceptible to depletion because of their biological characteristics (long lifespan, late maturation, low fecundity, slow growth, etc.). They have therefore been considered separately from other bottom resources. The top panel of **Figure 16** shows the existence of 2 distinct periods of development of very similar aspect but different levels of production separated by a gap of about 20 years. In this analysis, it will be considered that the second peak represents the maturity stage of the concerned area but it cannot be excluded that a first important period of senescence (and even collapse) already happened between 1970 and 1990. Indeed, as mentioned earlier, the history of collapse of directed shark fisheries in the 1960s reinforces this idea.

Lobsters are highly priced resources and as such are expected to be intensively exploited. Surprisingly, the smoothed total landings keep rising until the early 1990s (close to 9,000 tonnes) and decline rapidly to about half that amount in the following decade followed by a hint of a recovery. The pattern is rather similar to that of the Bottom Fish category.

Shrimp resources production has been rising and is oscillating around 30,000 tonnes. The species composition available is too incomplete to see whether the increase is the result of a deep extension of the fishing grounds (towards deep sea shrimps) or an increase in underlying biomass (from reduced natural mortality) or both. The continuous increase in the landings of shrimps and cephalopods (see below) reflects perhaps both: (1) an improved separation from the other landings as well as the development of specific fisheries towards these species as the world market developed, and (2) their relative increase in the ecosystem as a consequence of the reduction of their predators (Pauly et al, 1998; Sainsbury 1987). In the second case, the cascading effects of the Canadian cod stocks collapse on the lower food web levels have been well documented (Bundy and Fanning 2005; Frank et al. 2005; Fisher et al. 2008).

The landings of the Squids, Cuttlefish & Octopus category contain a mixture of fairly different animals with different roles in the ecosystem. The landings have been rising until the mid-1990s and may be stabilizing around 60,000 tonnes. Many of the species concerned are preys and are expected to increase in productivity as their predators are depleted.

Figure 16: Mediterranean-wide landing patterns: Sharks & Rays (SRL5); Lobsters (LL5); Shrimps & Prawns (SPL5) and Squids, Cuttlefish & Octopus (SCL5)



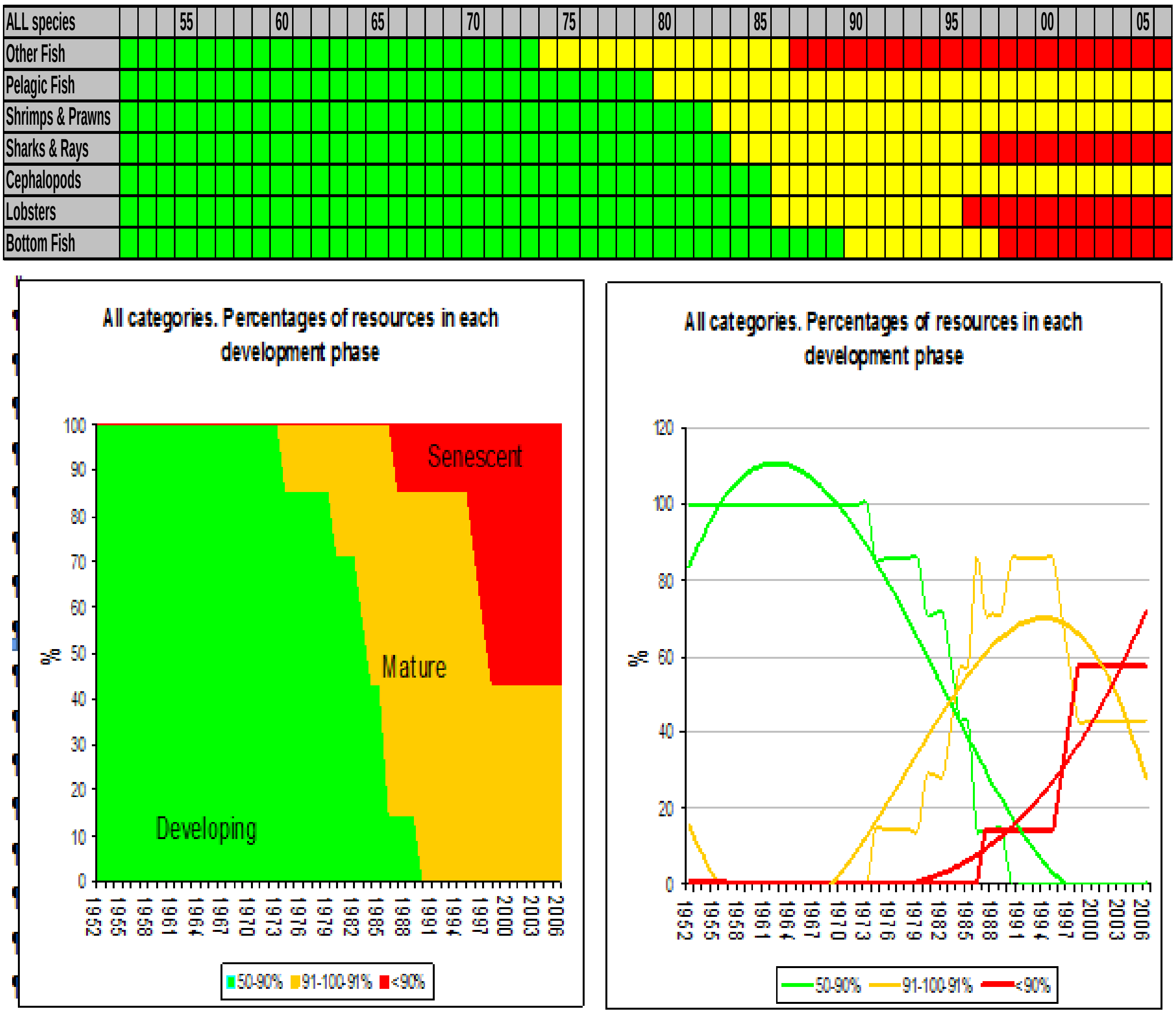
Note: Left: Landings (thick line) and Rate of increase (ROI, thin line). Trend lines (3rd polynomial, dotted lines). Right: phase graph: The sense of the trajectory is indicated by the dotted grey line. The last point (2006) is the largest square.

Conclusions

At such a high level of aggregation (the entire Mediterranean) the conclusions are relevant for the Sea as a whole as the data send a large scale signal. In particular the mechanisms behind the observed patterns are not immediately obvious:

- The TL production has been stable for close to three decades. The political turmoil that has affected some important production areas (e.g. Adriatic, Levant) might be in part responsible for this fact.
- The Pelagic Fish (PL) production is still growing, possibly due to organic enrichment (pollution) or trophic cascades resulting from the depletion of predators.
- The Bottom Fish (BL) production has been decreasing for 2 decade, probably signaling that a critical threshold has been crossed in many sub-areas.
- The decreases of Sharks & Rays as well as Lobsters during the same period send the same type of signal.
- Shrimps and cephalopods have been increasing (and cephalopods may indeed be reaching an asymptote) that could indicate increased targeting at deep sea shrimps (e.g. in the Ionian Sea) and perhaps also a trophic cascade effect although the latter is pure speculation with the knowledge available today.

Figure 17: All Categories 1952-2006. Top: Development phases.



Note: Development (green), Maturity (yellow) and Senescence (red). Resources arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of selected resource categories in the various development phases.

Figure 17 (top) regroups the different patterns observed in this section into one synoptic pattern. It can be noted that the fisheries development systems targeting the various resource categories reached maturity between 1975 and 1990. The fact that, as a whole, the Pelagic Fish category moves into Maturity a decade before the Bottom Fish category is unexpected. The Other Fish category, which contains a significant part of bottom fish, appears to have reached maturity first. However, considering that this category contains a significant part of bottom fish and that its trend is probably, to a great extend probably related to improvement in fish identification in statistics and in the market, no conclusion should be drawn from this over-aggregated data, noting however that all selected resources are presently at maturity or senescent. **Figure 17** (Bottom) shows the overall state of the set of main resources and gives a clearer idea of the general chronology.

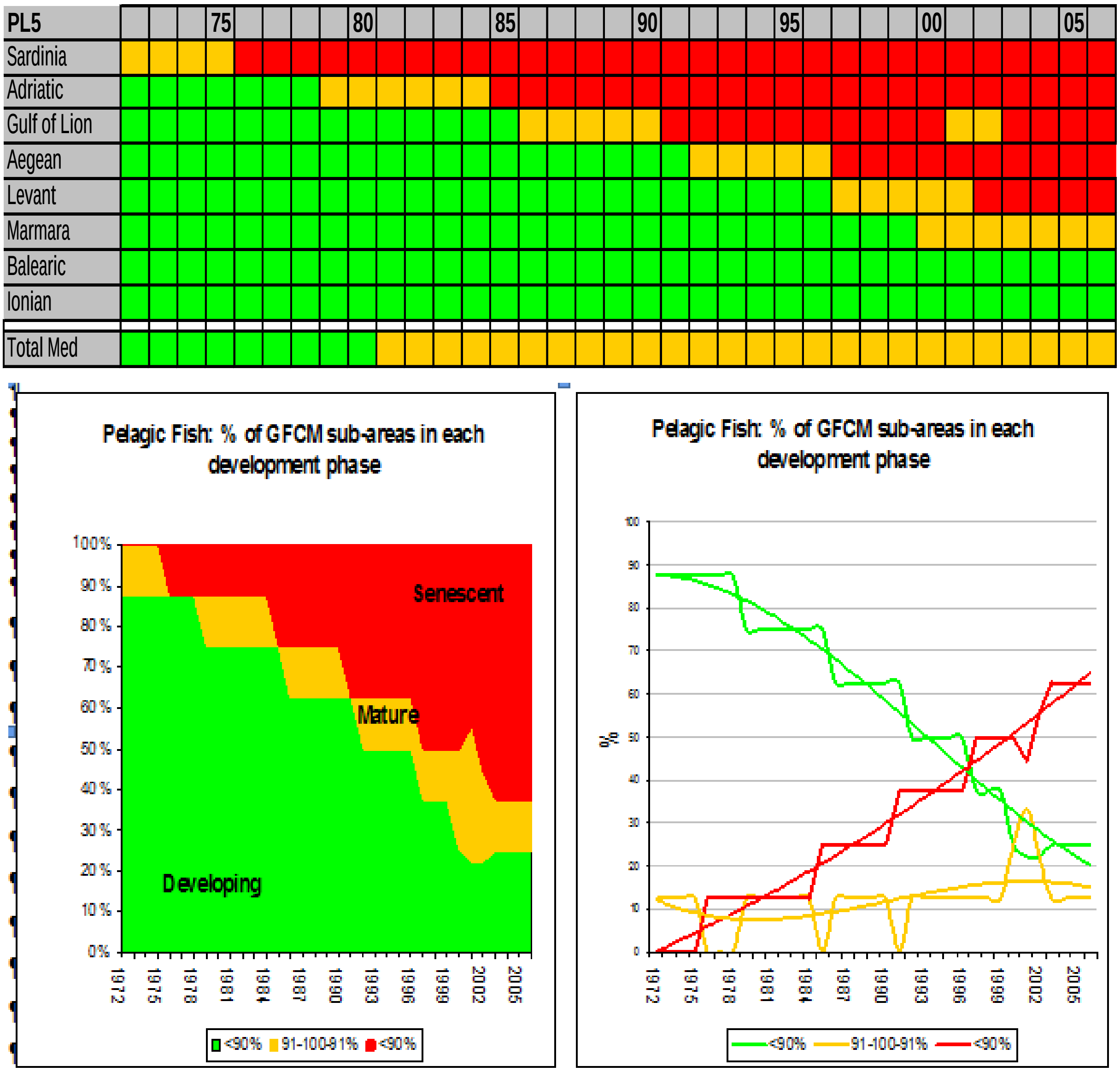
2.4. Sub-regional development cycles: 1970-2008

The patterns in landings and growth rates have been drawn for the various sub-areas and for main selected resources categories (BL, PL, OL, and TL). In this section, we will look at the evolution of the resources categories at sub-area level. The total for a given category, across all sub-areas (i.e. the Mediterranean-wide pattern) has already been examined above for the main selected categories with a longer time series. They serve in this section as background to the analysis by sub-area. The numerous graphs have been grouped for convenience in **Plates 2 to 8.** Synoptic representations have been developed to facilitate the overview on **Figure 18 to Figure 23.**

On **Figure 15**, the <u>Total Fish</u> landings for the Mediterranean have been oscillating slightly around a plateau for 25 years. The development cycles of the different sub-areas are shown in **Plates 2**. In some sub-areas landings have decreased since the early 1970s (Sardinia), early 1980s (Adriatic), late 1980s (Gulf of Lion), mid 1990s (Aegean), late 1990s (Ionian). The Levant landings seem to have been oscillating around their maximum since the early 1990s. In the Balearic and Marmara sub-areas, the landings are still increasing. The interpretation is complicated by the fact that the time series starts in 1970, when most areas (except Marmara and, to some extent, Levant) are already fairly well developed with important landings. As a consequence, it is not that easy to see if the oscillations observed (e.g. in the Gulf of Lion, **Plate 2A**) are showing a repetition of the full development cycle (development, maturity and senescence) repeated 2-3 times or simply natural and other oscillations at a level close to the maximum. Indeed, the phase graph seems to indicate that the fishery is oscillating around 35,000 tonnes and the trajectory has been materialized as a circle. In the synoptic graph below, it has been assumed that after the first peak, the oscillations were between maturity and senescence periods as the fishery system oscillated close to its maximum.

The total <u>Pelagic Fish</u> landings have stagnated around their highest level of production since 1980. The different development cycles observed in the different GFCM sub-areas are shown in **Plates 3**. The changes observed mimic quite closely the Total TL5 landings oscillations described above, strongly conditioned by the relatively more important pelagic fish landings. However, some sub-areas have experienced decreasing landings, i.e. since 1970 (Sardinia), the early 1980s (Adriatic), late 1980s (Gulf of Lion with oscillations) and early 1990s (Aegean). In other areas, landings are still growing, i.e. Balearic, Ionian, Levant (with oscillations), Marmara… and Sardinia, since the early 1990s, following their collapse in the 1980s. The synoptic representation (**Figure 18** top) shows clearly the progressive decrease in the state of development from the Western Mediterranean (top left part of the figure) to Eastern Mediterranean (bottom right part of the figure). Although there could be many reasons for the Eastern fisheries to be in a least advanced stage of development than in the West, one should be logically the fishing pressure.

Figure 18: Pelagic Fish (PL5) 1970-2008. Top: Development phases of GFCM sub-areas



Note: Development (green), Maturity (yellow) and Senescence (red). Sub-areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of sub-areas in the various development phases.

Each sub-area, however, corresponds to a different level of productivity. The potential of the Sea of Marmara, for example is much lower than the potential of the Ionian or Aegean Sea. The chronology of the different development phases (**Figure 18**, bottom panel) illustrates: (1) the sequential decrease, from 1972 to 2008, of the proportion of sub-areas in early development state: (2) the early progression and decrease since the early 1980s of the proportion of sub-areas in intensive development and (3) the parallel increase in the proportion of areas mature and senescent, at about the same rate. Since the early 2000, all sub-areas except Balearic and Ionian are either mature or senescent.

At the Mediterranean level, Bottom Fish showed a clear unimodal production cycle peaking in 1990-1995. The development cycles in the different GFCM sub-areas are shown in **Plate 4**. The patterns, when compared with the Pelagic Fish ones, are sometimes similar (e.g. for the Aegean or Levant) but most often different. Many sub-areas sow decreasing landings, i.e. since the beginning of the series in 1970 (Sardinia), late 1970s (Adriatic and Balearic, with an apparent recovery of the latter since the 1990s), mid 1990s (Ionian and Levant, with oscillations) and early 2000s (Marmara). **Figure 19** (top) shows a pattern similar to that observed for Pelagic Fish with a faster progression towards senescence, something we expect considering their higher economic value. The first column shows also clearly that the West-to-East trend noted earlier is apparent also for these resources. Contrary to the Pelagic Fish, however, all Bottom Fish fisheries are presently senescent. The overall trajectories are given in **Figure 19** (bottom). The interesting point here is that the Bottom Fish landings practically declined everywhere. If fleet catches have not been constrained by management, their decrease could indicate a progressively spreading of overfishing. During the studied period, it seems that only the European Union member countries have had to reduce fleet size (since 1980), potentially constraining their landing capacity. However, the EVOMED (2010) analysis indicates that the effective fishing power has not been affected and the more conventional assessments made under the aegis of the GFCM (see section 6.4.2-Validation of results) confirm the poor state of the demersal resources. In the absence of any evidence of environmental factors, the most likely assumption is that this Mediterranean-wide decline in bottom fish landings is a result of widespread overfishing.

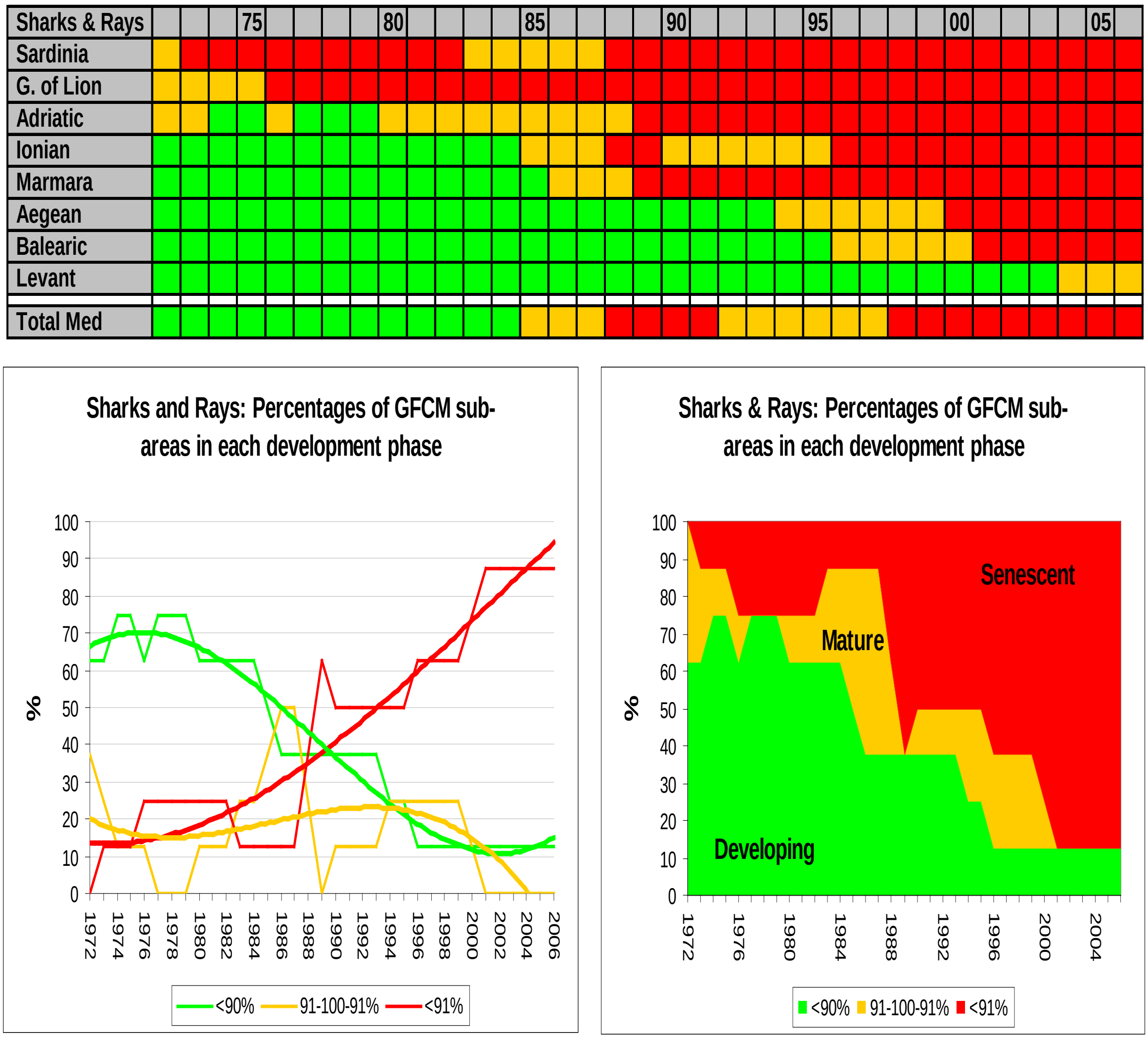
Figure 19: Bottom Fish (PL5) 1970-2008. Top: Development phases of GFCM sub-areas.

Note: Development (green), Maturity (yellow) and Senescence (red). Sub-areas arranged in ascending order of the date of entry into maturity.
Bottom: Yearly percentages of sub-areas in the various development phases.

Comparing **Figure 18** and **Figure 19** bottom panels, it is rather easy to see that in the case of Bottom Fish, all phases proceeded faster, peaked earlier, with earlier transitions to the next, more intense development phase. This is a difference one would expect when dealing with more commercially valuable resources.

The Shark & Rays pattern had shown two major oscillations, separated by a gap of about 20 years, for which there is a strong suspicion of repeated overfishing. In the GFCM database, and hence in the synoptic graph, only the second oscillation is present. The sub-regional analysis of trends shows clear differences between sub-areas (**Plate 5**). The landings have been declining in the Adriatic (since the 1980s with a sign of recovery since 2000) and in the Gulf of Lion and Sarnia areas (since 1970 at least). They have been increasing instead in the Aegean (which may have reached an asymptote since the mid 1990s) and Levant (since the early 1980s). The Balearic pattern is more complex with two clear production peaks in the early 1980s and in the 1990s. In the absence of any information regarding the reasons for these oscillations, they were interpreted as two phases of development towards the maximum asymptote of the concerned area. There is a suspicion, however, that these two oscillations signal two periods of overfishing. The Sea of Marmara shows a sharp decline in the late 1980s, followed by a clear "recovery" since the mid-1990s. **Figure 20** indicates a fast development in the 1970s, an oscillating plateau in the 1980s and 1990s and a decrease since then. All areas except the Balearic and the Levant areas are in senescence. The transition from intensive development to maturity and senescence (**Figure 20** top) appears particularly "noisy" with some sequences of senescence and apparent recovery. This might indicate old fisheries with oscillations due to environmental (circa decadal) or profitability-driven cycles. The bottom panels of that figure, however, show a very rapid passage from Development to Senescence, i.e. a very short period of "maturity" illustrating that these resources are not very resilient to intensive exploitation.

Figure 20: Sharks & Rays (SRL5) 1970-2008.

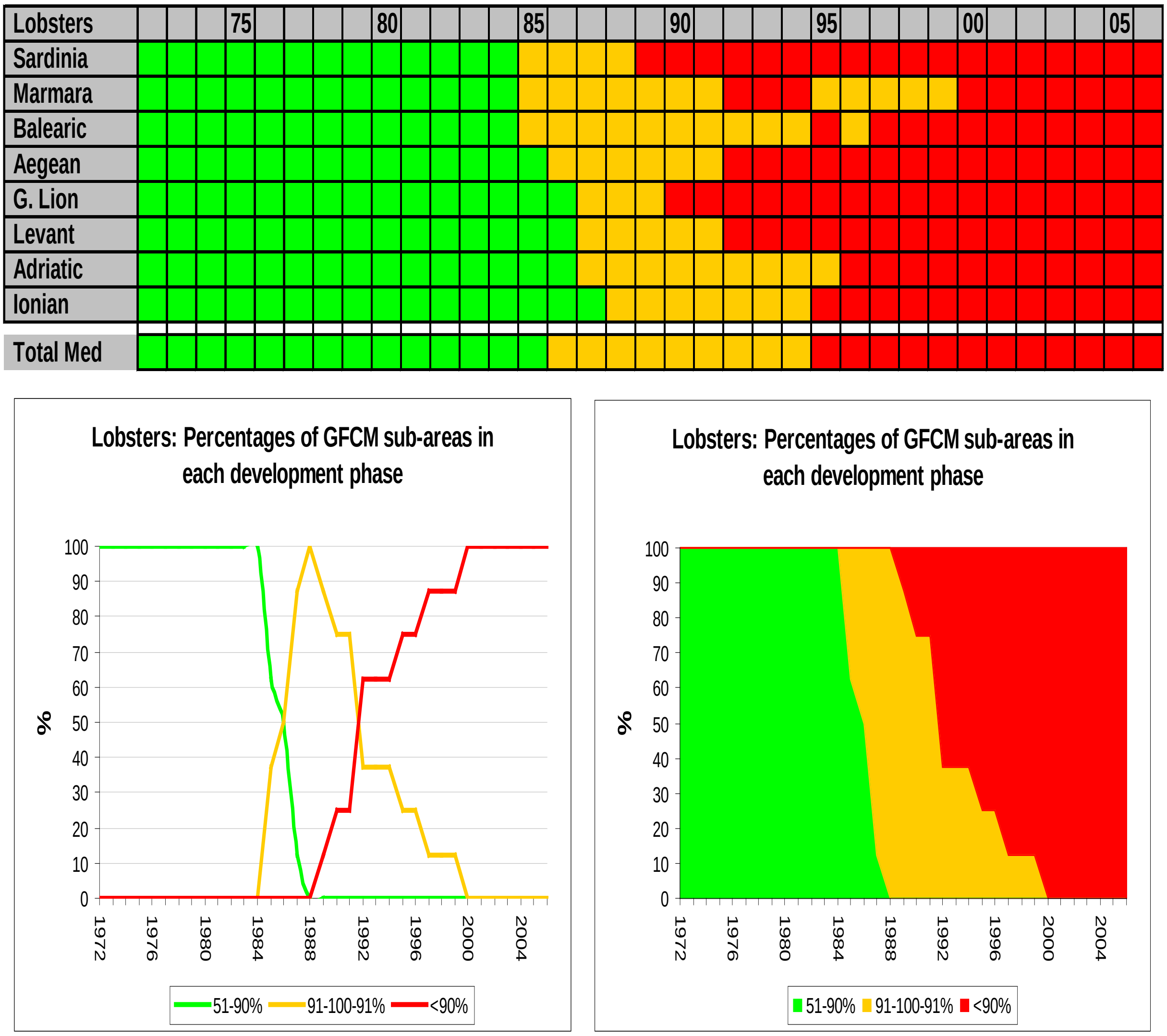


Note: Left: Landings (thick line) and Rate of increase (thin line). Trend lines (3rd polynomial) are dotted. Right: phase graph: The sense of the trajectory is indicated by the dotted grey line. The last point (2006) is the largest square

<u>Lobsters</u> are also, a priori very vulnerable because of their high economic value. At the whole Mediterranean level we saw an increase in landings until the early 1990s (close to 9,000 tonnes) followed by a rapid decline to about half that amount in the following decade and perhaps a hint of a recent starting recovery, following a pattern similar in shape and timing to that of the Bottom Fish category. The details by sub-area are given in **Plate 6.** A common trait of all patterns is indeed a production peak in the 1980s followed by an important period of senescence in the 1990s, sometimes followed by a hint of recovery in the most recent years. This common pattern is more clearly visible on **Figure 21**. The most striking aspect

of this pattern is its homogeneity across areas as shown on **Figure 21**, top). Except in the early development phases there is little noise. The development seems to have been occurring at the same time in the whole Mediterranean. Maturity was reached everywhere between 1985 and 1987 and senescence followed within 3 to 10 years. The chronology of the different phases is also visible in **Figure 21** (bottom). On the left panel, the trend lines have been omitted because the transitions are so abrupt that the polynomial trend line would confuse the vision instead of assisting it. The simultaneity of the patterns and the rapidity of the transitions to senescence could be seen as characteristic of highly priced and vulnerable resources with a large market available locally (for the local tourism) and regionally (in the big capitals such as Rome, Athens, Istanbul, etc.).

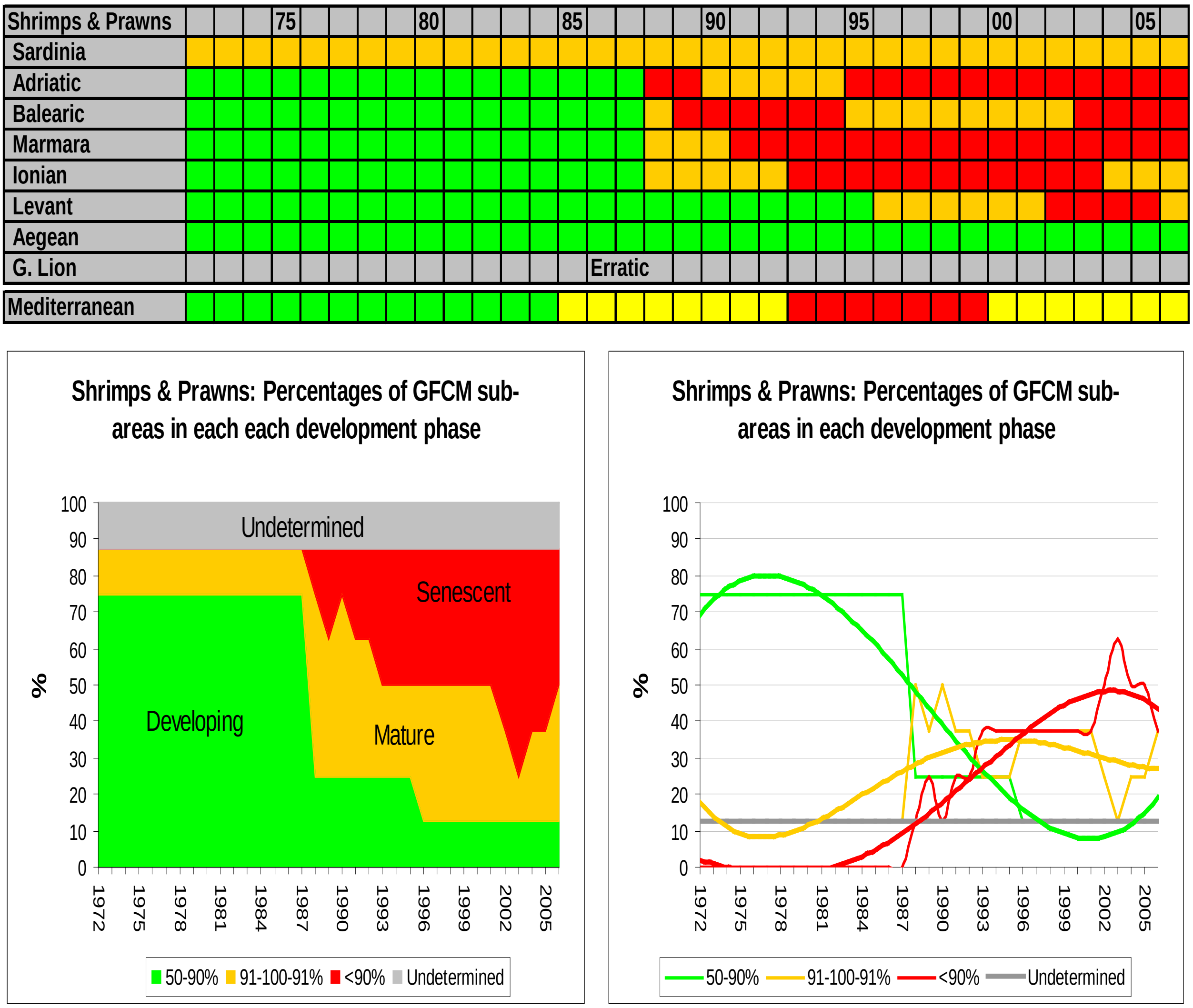
Figure 21: Lobsters (LL5) 1970-2008. Top: Development phases of GFCM sub-areas



Note: Development (green), Maturity (yellow) and Senescence (red). Sub-areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of sub-areas in the various development phases.

Shrimps have not been processed together with the other Bottom Fish resources for two reasons: (1) they are of extremely high value and (2) being preys, their expected decrease under excessive fishing pressure may be slowed down or indeed reversed as their natural mortality is reduced through the fishing out of their main predators. At the Mediterranean level, shrimp production rose rapidly in the 1980s and is still growing albeit at a lower rate. The sub-areas landing patterns are shown in **Plate 7**. They tend to be characterized by large oscillations (e.g. in the Balearic, Gulf of Lion, Ionian, Marmara and Sardinia sub-areas). In some cases, as in the Gulf of Lion and Sardinia areas, the oscillations without trend create an uncertainty as to whether the oscillations represent repeated cycles of development-maturity-senescence-recovery or whether they are simply the result of multi-annual natural fluctuations around the long-term asymptote, indicating maturity but without knowing at what level compared to the long-term potential of the area. For Sardinia, considering the very long and highly competent tradition of fishing, it was assumed that the area is oscillating around its long-term maximum and is therefore at maturity. For the Gulf of lion, the data appear too erratic and the area was considered as undetermined. Considering the value of the resources, the means available and the rich local markets of the area, it is unlikely, however that this area is undeveloped or even developing. The overall pattern is summarized in **Figure 22.** The overall pattern is characterized by the now classical earlier development in the Western and Central Mediterranean. It is also characterized by the possibility of more than one period of maturity in the time series of a few (Adriatic, Ionian, Levant) many areas separated by periods of senescence and recovery. In general, the recovery phases are not easy to delimitate and separate from environmental noise and are therefore subsumed within the senescence phase (i.e. shown in red on the pictures). A curious and unexplained aspect of the landing patterns in the Gulf of Lions is the striking similarity of the patterns of most categories (but particularly Lobsters and Shrimps & Prawns) with three important oscillations.

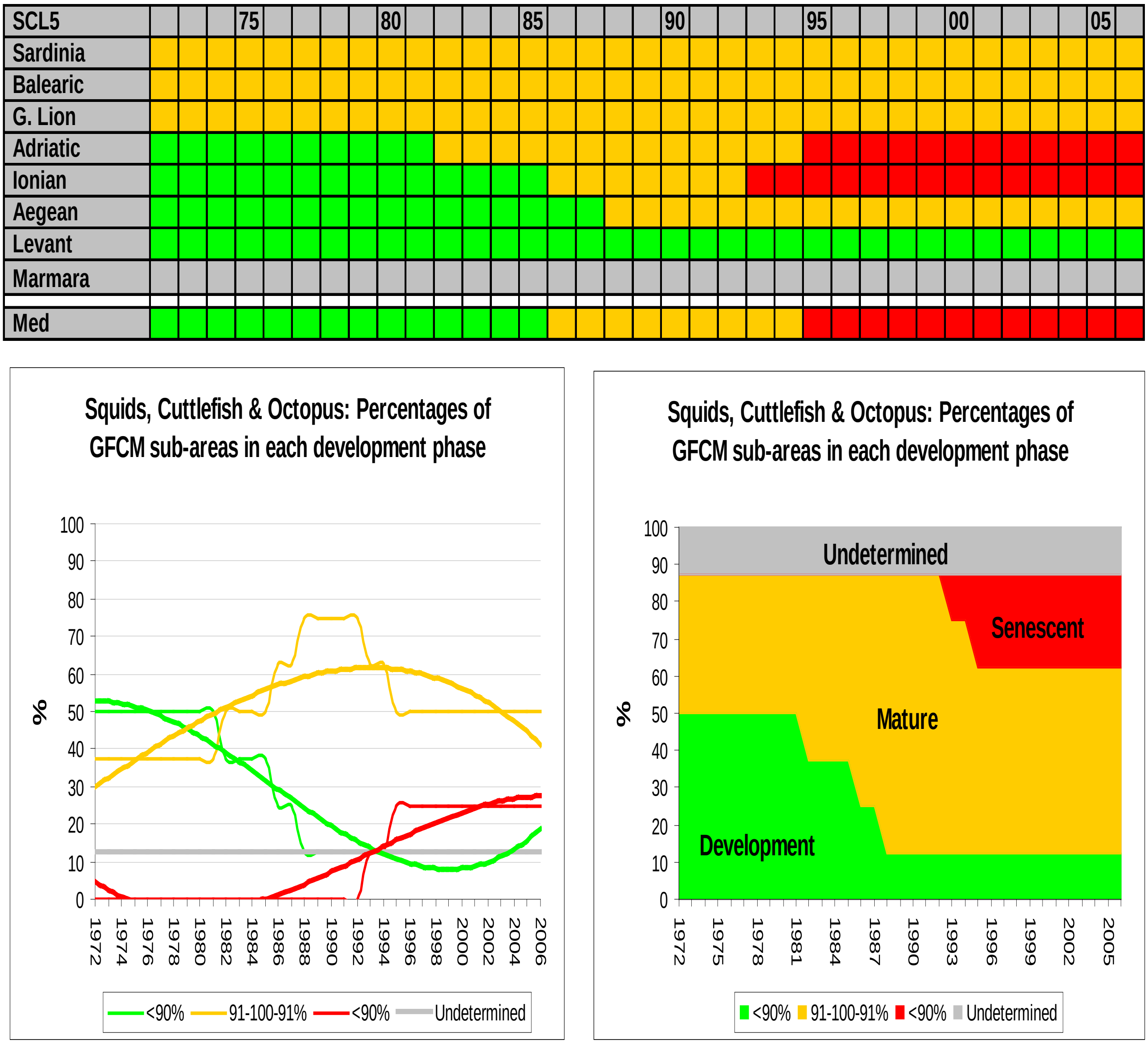
Figure 22: Shrimps & Prawns (SPL5) 1970-2008.



Note: Top: Development phases of GFCM sub-areas. Development (green), Maturity (yellow) and Senescence (red). Sub-areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of sub-areas in the various development phases.

At Mediterranean level, the landings of the mixture of cephalopod species included in the SCL5 category (Squids, Cuttlefish & Octopus) has been rising until the mid-1990s and may be stabilizing around 60,000 tonnes with strong oscillations. The sub-regional patterns are given on **Plate 8**. They are contrasted. In two areas we can observe a decrease: in the Adriatic (since the early 1980s) and the Ionian (since the mid 1990s). In a number of areas, the landings are stable or increase very slightly during the entire period: Balearic, Gulf of lion and Sardinia. In the Levant sub-area the landings are still raising. Synoptic representations are available on **Figure 23**. This figure illustrates the fact that, except for two areas which shown a classical development-maturity-senescence cycle, the fisheries appear either as oscillating without trend (in yellow) or still developing (in green). The difference between this pattern and, say, the lobsters' patterns is striking. However, because the stable time series (in yellow) give no indication of the pressure being exerted, this should not be automatically equated with widespread under-development.

Figure 23: Squids, Cuttlefish & Octopus 1970-2008: Top: Development phases of GFCM sub-areas.



Note: Development (green), Maturity (yellow) and Senescence (red). Sub-areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of sub-areas in the various development phases.

2.5. National level development cycles 1950-2008

The analysis undertaken at Mediterranean and sub-regional level can, in principle, be applied at national level, at least for those countries with enough data to analyze. As stressed earlier on (**Section 2.3**) the modern countries of the Eastern Adriatic Area could not be analyzed separately as their time series is too short and the analysis was conducted on the resources of the Former Yugoslavia Area (FYA). The analysis was conducted only for the categories Total Fish, Pelagic Fish and Bottom Fish. Because the trends are always difficult to explain when pelagic and demersal species are mixed, the analysis of the TL data was very succinct. Synoptic graphs were only reduced for the Pelagic Fish and Bottom Fish categories.

In a number of cases, the diagnostic was impossible, for one or more of the following reasons:

a) Very noisy data, both in landings (usually very small) and growth rates, masking the long-term trends. In these cases, it was considered that there was no trend and that the pattern was undetermined.

b) Interrupted time series. This is the case of the former federation of Yougoslavia, which have disapeared in 1990, making the assessment of the present situation irrelevant as well as impossible.

c) Too short time series. This is the case with new countries, e.g. as those emerging from the collapse of the federation of Yugoslavia, for which the initial development time series have not yet been reconstructed. This is also the case of the Occupied Territory of Palestine.

In addition, some patterns have been likely affected by wars and other political perturbations and can only be tentatively interpreted wiuth caution.

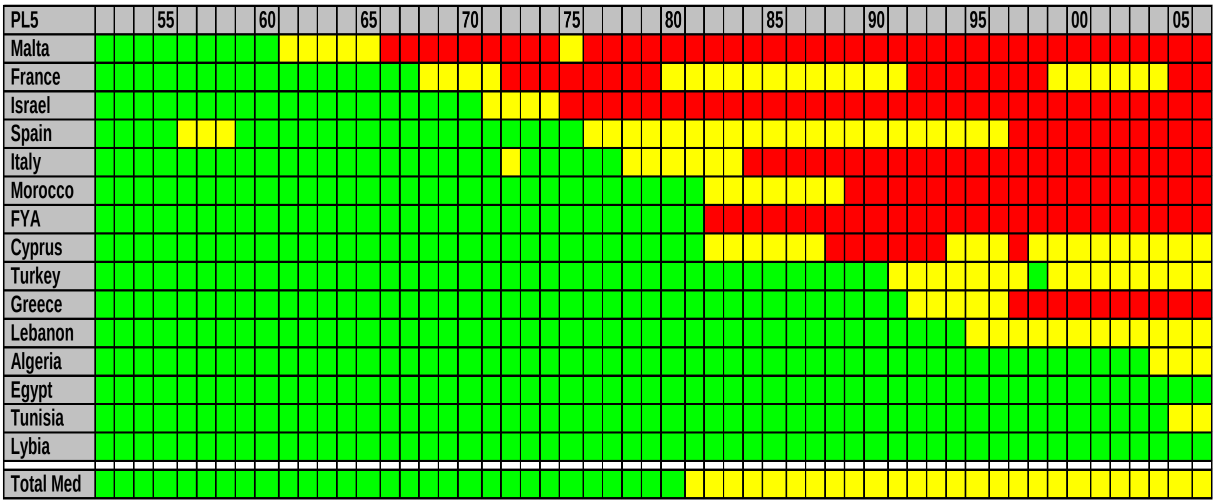
No national-level analysis was made within the GFCM sub-areas (e.g. separating the different Home Areas of countries fishing in more than one sub-area) or by disagregated resource types. This was not foreseen in this study and the interpretaion of trends at such detailed level could be very problematic if not supported by additional information on sub-national development policies and sectoral data on exploitation trends, when available. Such analyses should rather be undertaken by national scientists in collaboration with policy-makers and fishers representatives.

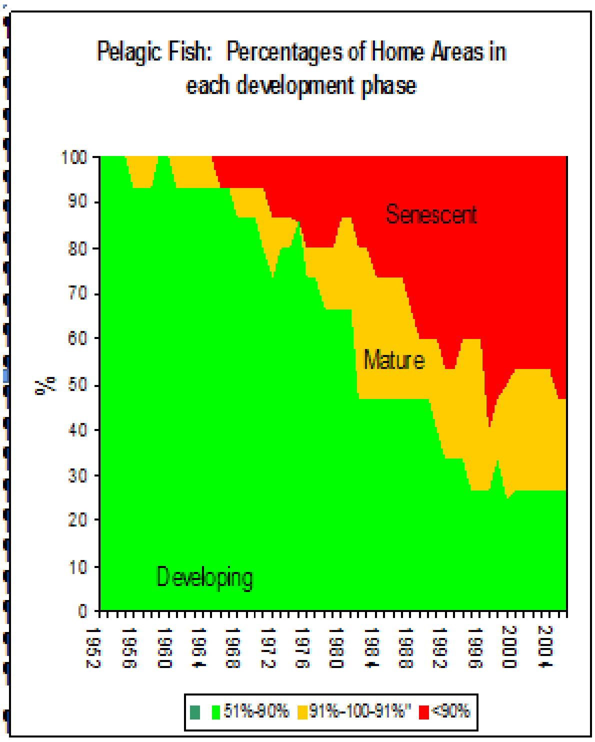
The interpretation of the larger-scale national data given in this report analysis should, in any case, be considered only as preliminary and should be checked against other biological, economic and market information that might be available at national level.

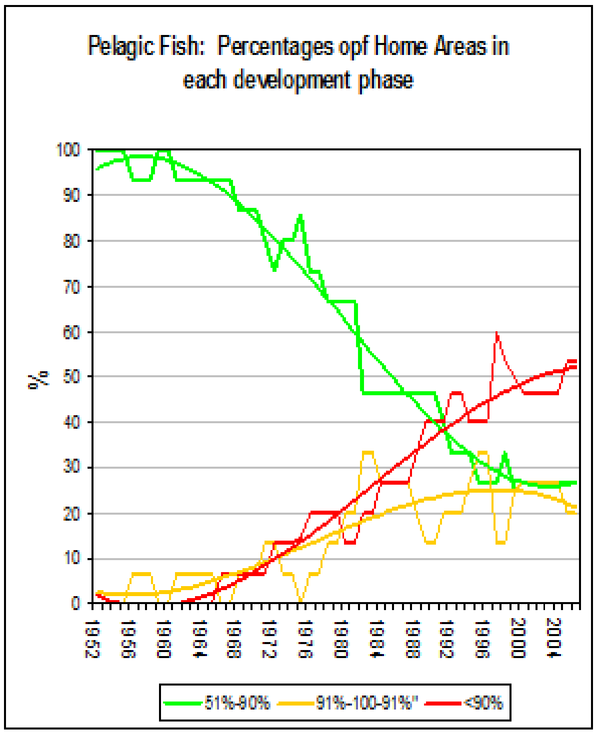
The Total Fish national patterns are available on **Plate 9**. The information available is not easy to summarize usefully. If the countries are grouped by type of development pattern and current situation, the results are as follows. Overall, 35% of the number of Home Areas are still developing: Algeria, Egypt, Syria, Tunisia, Lebanon, and Libya. Maturity has been reached and maintained in 18% of them: France, Morocco and Turkey. However, in 41% of the areas the sector as a whole appears in decline: Albania, Cyprus, Greece, Israel, Italy, Malta and Spain. The only area (6%) which, at thet level of aggregation, seem to present signs of recovery is the Former Yugoslavia Area, following a deep decline which could be connected to the troubles period of dissolution of the Federation of Yugoslavia and the ensuing wars (1970-2003). At that level of aggregation, the situations are not easy to understand and the patterns of the Pelagic Fish and Bottom Fish, a priori more homogenous, have been studies in more detail and are presented in the next sections.

The national patterns for Pelagic Fish are available on **Plate 10**. They tend to be very similar to those observed for the Total Fish category, dominated as the latter is by Pelagic Fish landings. The data show that 41% of the areas are still developing: Algeria, Cyprus, Egypt, Lebanon, Libya, and Tunisia. Syria seems to be in the same group but its time series is too short to be sure. Maturity has been reached and maintained albeit with strong oscillations in 18% of them: France, Morocco and Turkey. However, in 29% of them the sector has fallen in long-term senescence: Greece, Israel, Italy, Malta and Spain. Finally, one country (6%) may be recovering (the Former Yugoslavia Area) and another (6%) remains undetermied (Albania). A synoptic representation has been developed to give a better idea of the various national developments (**Figure 24**). In general, areas exploited by developed nations in Western Mediterranean have reached maturity earlier than areas located in the South and the East. About 25% of the Areas are developing at present, 20% are mature and over 55% are senescent.

Figure 24: Pelagic Fish (PL5) 1950-2008.



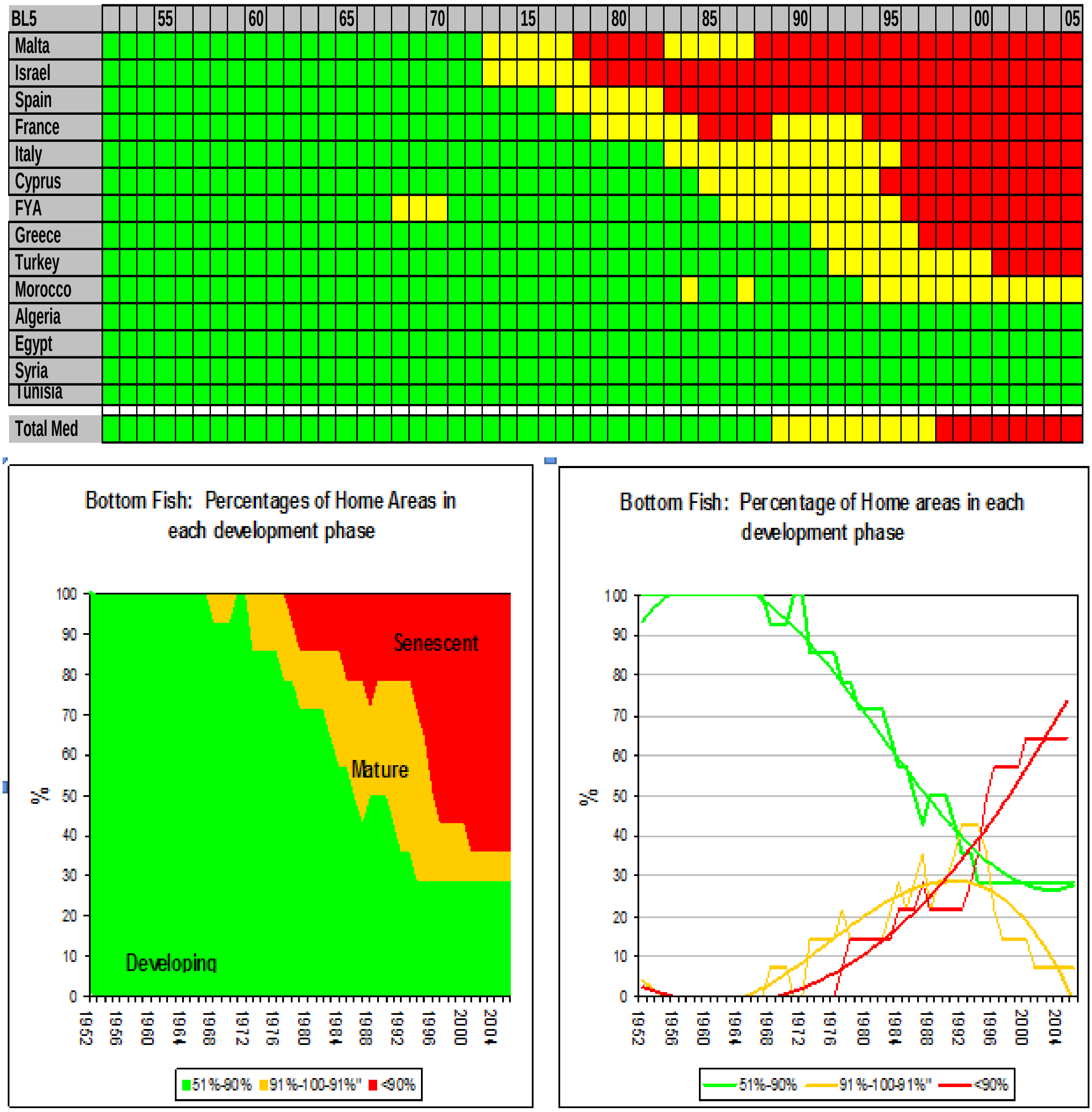




Note: Top: Development phases of Home Areas. Development (green), Maturity (yellow) and Senescence (red). Home Areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of Home Areas in the various development phases.

Bottom Fish national patterns are available on **Plate 11**. The figures show that 18% of the areas are still developing (Algeria, Egypt and Tunisia); 6% are mature (Morocco); 47% are senescent (Cyprus, France, Greece, Israel, Italy, Malta, Turkey and Spain) and one area (6%) is recovering (FYA) while 24% of the areas are undetermined as the time series is too short to be safely interpreted (Albania, Lebanon, Libya and Syria). The synoptic representation (**Figure 25**, top) is much less noisy than the Pelagic Fish one, as expected for longer-lived species. The interspersed periods of senescence and maturity in the transition period of the pelagics reflect perhaps a higher amplitude of natural fluctuations. Strangely, the maturity has been reached for pelagics about a decade earlier than the demersals. But because of the fluctuations, the percentage of senescent resources is higher and more stable for demersals. The top diagram does not present the usual West-East gradient. The analysis should be taken with a "grain of salt" because the four "undetermined" patterns, not represented in the figures, belong to emerging and developing economies, mainly from the eastern Mediterranean, which, based on previous experience would be expected to result as developing.

Figure 25: Bottom Fish (BL5) 1950-2008.



Note: Top: Development phases of Home Areas. Development (green), Maturity (yellow) and Senescence (red). Home Areas arranged in ascending order of the date of entry into maturity. Bottom: Yearly percentages of Home Areas in the various development phases

Plate 12 contains the development cycles for the Other Fish category. But considering how little is known of the composition of this group and the possible changes with time, no detailed analysis was conducted.

VI. Discussion

Areas requiring discussion include: (1) data quality; (2) interpretation of the development cycle phases; and (3) the relation with the state of the resources.

1. Landing data quality

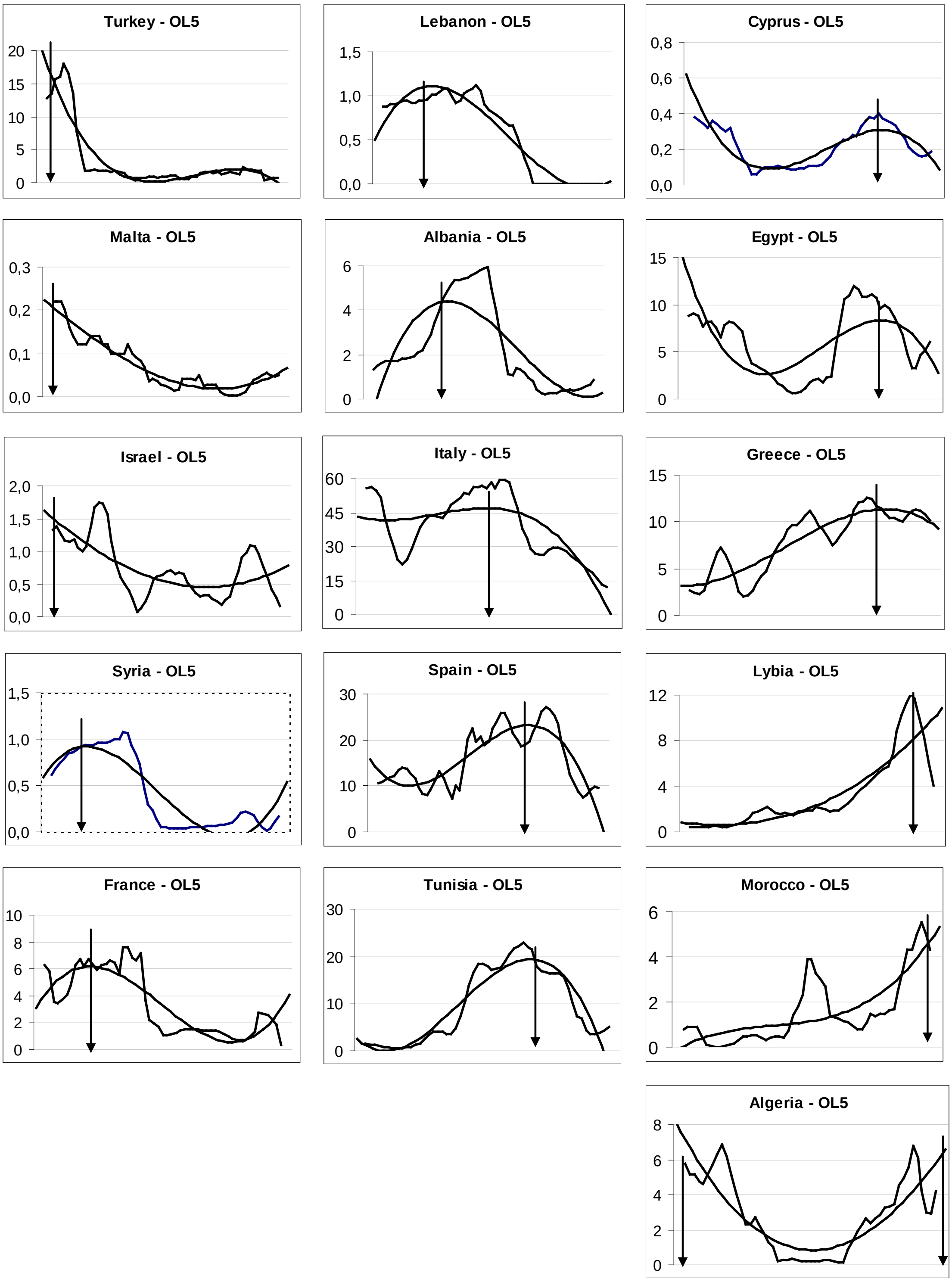
The landing data used in the study reflect necessarily the capacity and quality of the national information systems that collect and process the basic information. The problems potentially affecting the quantities reported and hence the detected trends include:

- Artisanal fisheries. They_are often not properly covered by national statistical systems, particularly in remote areas. The raising factors used to calculate total landings from sampling data may not be updated often enough. The way auto-consumption is accounted for (or forgotten) is not always clear. Sport and recreational fisheries, particularly important in the Mediterranean are most often not formally recorded. This may lead to underestimates of production.
- Constructed landing records. It has been argued that, in some countries with deficient fisheries governance regular annual increases are "forced" in statistical reports to show comliance with official development plans. The result is a continuous quasi-linear development trajectory with litte real meaning.
- Discards. They are not systematically reported. At the world level, they have decreased from about 20 million tonnes in 1980-92 (Alverson et al. 1994) to about 7 million tonnes during 1992-2003 (Kelleher 2005), but their evolution since 1950 is unknown and a simple extrapolation of the two data points available to the entire time series, backwards and forward, would be extremely crude. For the Mediterranean, and Black Sea together, Alverson et al (1994) estimated that about 560,000 tonnes of fish were discarded per year between 1980 and 1990. In his new estimate, Kelleher (2004) has reported much lower discard rates for the following decade (1990-2000). For the Mediterranean, he reports discard rates of 20-70% for trawlers, depending on depth fished (average 45-50%), less than 15% for artisanal fisheries and a weighted average estimate of 4.9% overall, i.e. about 18,000 tonnes per year. The historical review undertaken on European bottom fisheries (EVOMED 2011) indicates that discards were practically inexistent in the post WWII period (limited to damaged fish) as there was a market for everything that was caught. Discards increased (perhaps with the standards of living) since the 1970s together with the size and power of the fleets (and perhaps with the discovery of new species in deeper waters that the traditional market did not readily accept). If these conclusions are combined with those of Alverson et al. and Kelleher, the discards have also decreased since 1990 to about 5% of what thay were in the 1980s.
- Illegal, unreported and unregulated (IUU) is usually considered a problem. The absence of EEZs in the Mediterranean eliminates the formal "illegal" (e.g. unauthorized) fishing by foreign vessels in EEZs. As there are no catch regulations, the incentives to misreport landings are limited but may still exist for tax evasion purpose. The GFCM has esttablished regulations on mesh sizes and prohibits fishing beyond 1000 meters depth. While the second is likely to be respected, there are doubts regarding the first. There are also constant rumours of infringement of the prohibition that exists in many countries to fish close to shore or in any case inside the 50 meters isobath. The patterns observed, are certainly affected by IUU to some extend and this factor in integrated de facto into the "prevailing exploitation patterns".
- Unidentified fish. The portion of the total catch reported as "unidentified" (and referred to as Other Fish (OL) in this study, has changed with time (**Figure 26**), due to various factors. The factors of increase of OL landings include: (i) degradation of the resources that may lead to lumping together fish that, if bigger, would have their own market, e.g the Mediterranean "soup fish". (ii) increased contribution of artisanal fisheries, the landings of which tend to be less well identified; (iii) emergence of an improved market for previously low-value or no-value species previously discarded (e.g. in aquaculture feeds). The factors of decrease may include: (i) development of a new market for previously low-value

species, justifying improved identification in auction halls. (ii) new (or better enforced) regulations prohibiting the landing of small sizes, promoting their discarding.

These potential errors, the detail and extent of which remain unknown, cannot be corrected "from outside" and have therefore been disregarded for want of a better solution. It is assumed that such errors do not distort the patterns to the point of making them misleading at the large scale at which they are examined. In addition, the approach used in this study is considered as providing only a first "rough" diagnostic which should be validated at lower level, for specific resources in specific countries, where more data might be available, e.g. to reprocess the OL category into the BL and PL categories.

Figure 26: Patterns in the reporting of fish landings as Unidentified



2. Fishing as the main driver

In **section 4.2**, dealing with the relation between the fishery development cycle and the state of underlying resources, it was stated that *the main assumption made in analysing FAO landings trends against the fisheries development cycle is that are that the long-term evolution of landings (over the 58 years of data available) reflects mainly the impact of fishing.* This implies that: (i) there has been no significant catch-constraining management measures; (ii) changes in discard rates and improvement in species identification of landings have not been sufficient to distort the long-term relation between fishing and landings; and (iii) environmental factors have not so gravely distorted the patters as to render them misleading. These considerations are elaborated below.

2.1. Management considerations

The first consideration is rather robust. In his general review of the Mediterranean fisheries, Bas Pereid (2006) describes Mediterranean fisheries as characterized by: (1) *widespread overfishing affecting all exploited species throughout the whole of the Mediterranean* and (2) *major socio-economic pressure exerted on the fishery activity, hindering to a large extent the setting up of restrictive measures which are necessary to improve the situation of existing resources.*

There is no tradition and even strong resistance in the Mediterranean fishery sector about regulating catches, in the form of TACs and *a fortiori* quotas.

Mediterranean fisheries management is still very conventional, based on so-called technical or conservation measures such as: (i) temporary closures for the protection of juveniles or spawners; (ii) banning of some gears in some vulnerable areas (e.g. trawling in *posidonia* fields, often in less than 50m depth) or to limit conflict with artisanal fishing (e.g. prohibiting trawling in the first 1-3 miles from shore. Summer closures of one to four months have been implemented in the Tyrrhenian, Aegean and Ionian seas; (iii) some no-take zones also exist since 2005 in the Tyrrhenian Sea; (v) mesh size regulations; (vi) minimum landing sizes; (vii) fishing time limitations[10]; and (viii) in some areas, voluntary occasional limitations of fishing effort by the sector to regulate the market. Many of these measures (except the last ones) are often weakly enforced at best[11]. Since the mid-1980s, a number of measures to reduce fleets and capacity have been strongly promoted by the European Commission (fleet reduction, limits on engine power etc.). In general, the numbers of vessels went down, the engine power (that had increased 4-5 times since the 1950s) also went down "officially" but not always in practice and, overall, considering an important "technological creep", fishing capacity in the latest decades have stayed very high (EVOMED 2011; see **section 6.4.2.3**).

Measures that could have slowed down the growth of fishing pressure may therefore have existed (even if their long-term effectiveness can be doubted) but measures to effectively decrease the levels of landings have been in effect only since the 1980s and apparently only in the European countries. Less is known however about what has happened in the emerging and developing countries but there is no information about structural adjustments of the fishery sector. A safe assumption is that, overall, little or no effective effort was made in these countries to deliberately cut down on harvesting capacity. The raising landing trends observed in these areas did not, in any case, provide incentives to do so.

Catch restrictions were therefore probably weak if not inexistent. However, that assumption may still be invalidated if Mediterranean resources were shown to be strongly affected by periodic or continuous environmental change. Certainly, the demonstration of the existence of environmental cycles with of a periodicity equal or longer to the observed period (58 years of available fishery data) would totally invalidate the assumption. Such cycles, with a periodicity of 100 years (as well as shorter cycles of 20 years) have been shown to exist for tunas (Ravier and Fromentin 2001; 2005). They may be less likely for resources with a much more limited spatial distribution such as those included in the landings categories considered in this study.

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[10] Historically fishing time has been constrained in some western countries, banning fishing on Saturdays, first, then on Saturdays and Sundays. In addition, trawlers forced to daylight fishing only with mandatory return to port for the night (Bas Pereid 2002: 385, EVOMED 2011).

[11] For example, Bas Pereid (2006) states *in many western fishing areas, the mesh used for trawls is substantially less that the one authorized, a very common offence committed by most boats. (P 384-85).*

2.2. Discarding practices

There is not much long-term data on discarding practices in Mediterranean fisheries. It would have been logical to assume that discards had probably decreased with time as scarcity increased and market improved, in parallel with the noted improvement on species identification and the decrease of fish reported in the Unidentified category. However, the EVOMED study in European countries pointed to very low discards rates before the fast development phase (in the 1950s and 1960s) and an increase with the development of fishing and trade, which apparently increased supply of high quality fish reducing the market for the others. It was also mentioned that discards increased when minimum size at landings were introduced. It is also likely that they have increased with targeted shrimp trawling. It is therefore hard to speculate on the impact of discards on the conclusions.

2.3. Environmental considerations

Long term pollution of the semi-enclosed Mediterranean with its highly populated and developed watershed is also a likely source of bias. Caddy et al. (1985) have assumed that the important organic pollution of this sea might have progressively raised primary productivity, increasing the size of small pelagic resources. If verified, trophic cascades should be expected to have also pushed upwards the value of the Long-Term Maximum Average Yield of most predators' resources. This would lead this study to underestimate the fishing pressure in the early years of the development cycles.

In the Eastern Mediterranean, the immigration of Red Sea species through the Suez (Lessepsian migration) and its converse (the "anti-Lessepsian migration) canal has created a completely modified fauna. Bas Pereid (2006) refers to 24 migrant species of crustaceans, 27 of molluscs and 68 of fish some of which have reached the Iberian peninsula. According to this author 25 species have become important of which 8 decapods and 13 fishes many of which supports a very large part of the local fisheries (e.g. species of the genus Upeneus, Saurida, Siganus) and represent a substantial part of the landings (50% of the red mullets for Upeneus, 80% of the decapods landed on the Israeli coast). We do not know whether this significant invasion has modified in any way the productivity of the ecosystem and contributes to the present increasing trend in landings observed in the area.

On the other hand, the same reasons have led to a well documented largely irreversible degradation of the coastal areas and coastal nurseries through development and chemical contamination. The total impact on the fishery resources has never been assessed and is presently confounded with the impact of fishing. This is one of the reasons why this study does not assume reversibility of the observed trajectories.

3. Empirical reference values

The study is intended to provide only a qualitative diagnosis but it uses, nonetheless, two quantitative reference levels: (i) the Long-Term Maximum Average Yield (LTMAY) and (ii) the zero-growth level itself.

3.1. The LTMAY

The LTMAY used to identify development phases and generate the synoptic views is calculated using the 5 consecutive highest landing values in the period where the long term declining growth rate hits the zero-growth line. It is assumed that, the fisheries development having reached that point, the likelihood for the fleets to detect important new resources of the conventional type in the Home Area or the region and to obtain significant increase in landings and potential is very slim or nil. We do not, however, equate this maximum with the aggregate theoretical Maximum Sustainable Yield of the resource, Home Area or GFCM sub-area for the following reasons:

- The maximum could be partial: If the stocks concerned are shared with neighbouring areas, it corresponds only to a part of the total potential in the specific area concerned and reflects an informal "sharing" among those who access the resource.

- The maximum could be transient: It only reflects a saturation point in the relations between the fisheries and the resources of an area. It could change in level or composition if new opportunities emerge, e.g. a new fishing technique making unavailable resources accessible; A new market justifying the exploitation of previously unused resources (uncaught or caught and discarded); the development of new stocks, e.g. because of climate change or Lessepsian migration. It could also decrease because of coastal degradation and contamination.

- The maximum is only one among others. Even when the "absolute" maximum is reached on average, it is only one of the many maximums that could have been reached with different fishing and management regimes and a different long-term climate or market background. It is therefore an empirically realized maximum, reflecting historical ecological and socio-economic patterns with higher weights for the more recent time intervals and events. It reflects the high point of a fishery, or a national or regional fishery sector development trajectory and it is different from the ideal maximum that the conventional MSY represents. It may be closer to the "multispecies MSY" we might have calculated having at hand a reliable model capable of handling so many species and fisheries simultaneously. This is not the case and this calculated MSY would, in any case, be as "virtual" as the conventional MSY, stained by assumptions of homogeneity, equilibrium and reversibility.

- The relation between nested LTMAYs: LTMAYs can be empirically determined for a national Home Area, a GFCM sub-area, the Mediterranean as a whole and indeed any other areas the GFCM would find most appropriate for management. The sum of the elementary LTMAYs (e.g. of all Home Areas in a GFCM sub-area) is not the LTMAY observed for that larger area. The reason is that, historically LTMAs for different sets of resources in an area and for different small areas in a larger one will not have been reached simultaneously. As a consequence the sum of the elementary LTMAYs is likely to be higher than the empirical LTMAY obtained when observing the total landings pattern. The different plates available illustrate this when comparing the Mediterranean-wide patterns with the national ones, or the individual resource patterns with the regional aggregate. Nonetheless, the pattern shown in a Home Area, and the factors driving it, contribute to the overall situation and to the higher level pattern. Protracted stagnating or negative rates of increase in national fleets' landings would indicate either that the resources in the wider area are declining or that the specific national sector's marginal efficiency (i.e. its capacity to grow) is stabilized or decreasing, or both. If other fleets intervene, the resources may be decreasing under the total fishing pressure in the area even if the national fleet does not grow. It may also be that the national fishery has become ineffective (e.g. because of ageing, lack of maintenance, lack of replacement funding, lack of competitiveness with other fleets, etc.) or both. In any case, the diagnosis is useful in that it flags the need for remedial action to reduce national capacity, renew development incentives, improve the fishing pattern, facilitate adaptation to new conditions, etc. The most appropriate instrument will depend on the most likely causes for the present situation and these should be determined combining conventional assessment, fishermen's information, etc. in a comprehensive participative assessment, nested in an adaptive management process.

In this analysis, no attempt was made to forecast the LTMAY when it was apparently not yet reached as the focus is put on determining whether or not and when an empirical potential has been reached, whether the fishery managed to "sustain" that maximum or not and what is the "present" situation (i.e. in the last decade). The answers to these questions are seen as an introduction to a debate on what might be the needs for change in policy towards "good governance" and effective management.

No fishery model is available to safely forecast the LTMAY with only catch data at hand. However, in case the long-term rate of increase has already started to clearly decline, a limited statistical extrapolation could be made to get a likely value for that LTMAY as a rough estimate of the level of production the sector might reach under the prevailing conditions, taking account of the observed variability to calculate variance, and indeed recognizing the need to redo the extrapolation regularly as new data come in adjusting regularly the extrapolation as new data come in.

For the same reasons, when the maximum has apparently been clearly passed years or decades ago, (i.e. the fishery is in Senescence), the historical trajectories results from the interaction of complex and changing ecological and socio-economic forces the impact of which may not be easily reversible. There can be no certainty that the historical maximum could be "recovered" exactly, whether in terms of quantities or species composition. Measures might be taken, nonetheless, to improve either the national fishing sector efficiency (if that was the issue) or the management of the resources, or both to move towards it. Again, the clue should come from a closer examination of more data, at local level, particularly about the past development strategy, or the size of species at the market, and the final interpretations should involve the local scientists and the industry. In any case, a strict "return to the past" should never be taken as granted.

<u>The important point is that, when the landing patterns are indicating a protracted period of Senescence - and particularly if there are other signs (e.g. small fish sizes, erratic series, hard economic conditions) - one would have to look for arguments to prove that the concerning trends observed have nothing to do with resource depletion, shifting the burden of proof to the government and the industry who have provided the statistics in the first place.</u>

3.2. The relative rate of increase

The trend in ROI is central to the diagnostic, particularly when the maximum average reported landing has not yet been reached. The more clearly "logistic" (i.e. S-shaped) the left part of the landing development pattern (as shown on **Figure 2**), the easier it is to detect the trend of the ROI towards zero. This implies a strong acceleration at the initial stages of the development phase. The ROI may reach the zero value (and even negative values) many time during the development cycle if there are strong medium-term fluctuations in the process, of natural or socio-economic origin. However, the amplitude of these oscillations appears to decrease as a maximum is approached.

4. Pattern interpretation

4.1. Consideration of causal mechanisms

In **section 4.1** presenting the fishery development model, the different phases have been briefly presented. It is important, however to understand what factors might be at play in each of these phases in order to avoid simplistic conclusions and, much worse, erroneous management decisions.

Development phase

Many of the resources/areas examined, particularly in the eastern Mediterranean (e.g. **Plate 10**, Algeria or Libya), do not show a decrease in rate of growth. According to the model, the fisheries are still developing. This may indicate:

- <u>Under-developed resources</u>. The growth process of the sector may still be under way on a set of resources still exploited below their maximum productivity level. While the development may be further accompanied by the state, it would be important to put in place the needed development brakes and institutional references to avoid overshooting the sustainable development targets. The precautionary approach is very relevant here without intending to stop the development.
- <u>Sequential overfishing</u>. The traditional resources are being depleted but new resources are added at a faster rate through exploration, innovation, etc. This implies that the Home Areas may be still in an active process of extension, further offshore and deeper, possibly after having stretched traditional resources to their limit and beyond. In particular, the reaching of the end of the "developing" phase might be hidden by the sequential targetting (and possibly overfishing) of the Bottom Fishes and small Pelagic Fishes categories (cf. previous discusion under c) or by a progressive transfer of the Unidentified fish to the identified categories.

In case of doubt the trend in the observed levels of growth may help. While the erratic initial data of some time series produce very high rates of growth, these tend to fall rapidly to more reasonable ones. Experience indicates that on a long enough time series, rates of 5-10% per year on average are important rates, pointing to early development stages. On the contrary, rates of 1-2% or less indicate that the "maturity" is not far away. For precautionary reasons, border cases should be probably considered as close to fully developed, requiring closer resource-by-resource assessments and possibly new development policies and management strategies. The precautionary approach provided for in the FAO Code of Conduct and UN Fish Stocks Agreement has also an important role to play here.

Maturity phase

Many areas/resources appear to have reached maturity and have stayed there for quite some time. This is the case for small pelagic species globally but also for example for the Pelagic Fish in Turkey and France (**Plate 10**). A situation that one may consider as demonstraby sustainable despite fluctuations. This situation may also reflect different realities:

- Sustainability. The governance system has managed to develop a fishery system, the level of which is commensurate with the resources available. Considering the state of world fisheries, this would be quite an achievement. The hypothesis would become particularly plausible if the country concerned had put in place, early in its development, effective (modern or traditional) restrictions to access and fishing capacity;

- Economic constraits. The fishery sector of the country is constrained in its development (despite the non-limiting abundance of resources) because of lack of market, technology or financial resources. Considering the level of globalization of fisheries, the large market available in the Mediterranean, and the relatively wealthy status of Mediteranean countries among emerging and developing nations, this hypothesis is probably not the most likely in the Mediterranean but cannot be excluded *a priori*.

- Sequential overfishing. It is possible to maintain for some time the level of landings obtained from a given area, by progressive replacement of declining resources by new ones previously underexploited or unexploited. The latter might have been present in the area, but not targetted at because of its low economic value or inaccessibility (for lack of the proper technology). A very likely phenomena, observed in many areas, is that, within the Total Landings, the reduction of the Bottom Fishes resource base is masked by the growing production of the Small Pelagic Fishes. Similarly the composition of the Bottom Fish category tend to show a progressive diversification in part due to better species identification and in part to discard reduction and addition of new species to the target biomass. This process is usually accompanied by changes that can be observed, in technology and in areas and depth fished. The potential for sequential overfishing is always very high and could be checked by looking more closely at species composition of the Bottom Fishes landing category and if possible at the sizes landed.

While under this sequential pattern, senescence may not have started yet for any resource, or may be insufficiently characterized, it could be behind the corner if the instruments to effectively control capacity are not in place, eventually looking for diversion of fishing pressure to other dimensions of the sector. Considering the real difficulty encountered in reducing capacity, the temptation might be high to look for solutions such as aquaculture and value added products. For example, a better use of secondary species and discards and the transformation of raw fish into semi-elaborated and elaborated products (prepared meals) might be ways to maintain or increase the value of the production even if it stagnates or decreases in round weight. While these might be good complementary development avenues in well managed fisheries, they are also likely to be additional sources of rent drain in unmanaged systems, for example stimulating the increased capture low-value fish for aquaculture feeds, or forcing fishers to work harder on high- value fish to compensate for the decrease in market price due to the influx of cultivated fish on the market, pushing the systen further on its trajectory towards charaterized senescence.

Senescence phase

The decrease of landings during the senescent phases has to be interpreted carefully as it may reflect different realities:

- Voluntary decreases. The observed trend may reflects the policy of the country concerned to reduce catches, e.g. for stock rebuilding. The world history of fisheries development tells us that this hypothesis is highly unlikely for any declines observed before the 1980s. The explanation might be a plausible one, in more recent times, for single fisheries. It becomes much less plausible when dealing with the large aggregates of resources examined here. As stated earlier, we are not aware of any formal such restrictions in the Mediterranean but in some countries, the sector itself has sometimes restricted its landings, usually for short periods of time in seasons of high abundance, to rationalize the market.
- Economic disinterest. The trend may reflect a protracted period of fading economic interest in fisheries, leading to decreasing landings. Considering that fisheries are a globalized industry with growing demand, particularly in the Mediterranean and the documented growth of fishing capacity in the European coastal countries of the Mediterranean (EVOMED 2011), this assumption is rather unlikely in most cases. Moreover, such loss of economic interest might well reflect the decrease of the resource base (see below). The situation might also reflect a loss of competitivity of the national fishing sector. Considering the tendency of governments to suppress subsidies (particularly when facing difficult budgetary times, and the increase in fuel price), fisheries "recession" may, in the future, become more common than in the past. The comparison with the patterns shown by neighbouring countries and for the region as a whole could help lifting the uncertainty, if any.
- Resource decrease. The first expectable cause of a senescent fishery sector is a resource degradation. At local level, other confirming information should ba available: e.g. strong decrease in market sizes. A complication comes from the fact that a parallel decrease in fleet size or effort is not a good enough reason to assume that fishing pressure has decreased. Technological creep tend to keep the power of the remaining vessels very high and the reduction of the areas where the resources is concentrated increases fishing intensity even if effort decreases.

In all cases, long-lasting Senescence (sometimes starting from the onset of the data series, in the 1950s as in the Sardinia area) may reflect insufficient and failing governance and an urgent need for improved fisheries policy and management to stop the decline and possibly reverse it. While it may also simply reflect a progressive loss of interest of national investors for the sector, this should not be the first assumption and should be ascertained with other information at country level.

4.2. Validation of the conclusions

Introduction

The diagnosis, in terms of development phases may, in itself, be useful to understand the history and trajectory of fisheries development which, after all, is the backdrop of fisheries assessment. It would be important, however, to find out if this analysis and its conclusions are coherent with the conventional stock assessments available for the Mediterranean. The general trends are not surprising and in many instances surprisingly positive. Indeed, the general belief seems to be that the Mediterranean is poorly managed and hence badly exploited. Bas Pereid (2006) for example, in his synthesis, describes Mediterranean fisheries as characterized by: (1) *widespread overfishing affecting all exploited species throughout the whole of the Mediterranean* and (2) *major socio-economic pressure exerted on the fishery activity, hindering to a large extent the setting up of restrictive measures which are necessary to improve the situation of existing resources*. The point is stressed again indirectly by the Acting GFCM Executive Secretary who stressed the evidence that *general reduction of fishing effort was necessary to protect the demersal fisheries in the Mediterranean. The SAC was unanimously of the opinion that strong evidence exists which could allow the Commission to envisage strengthening of the resolution adopted at the last session and related to the general reduction of fishing effort on demersal species in all GFCM competence areas (GFCM 2010: Para 73).*

While not going in the level of resolution at which conventional stock assessment takes place, the present analysis gives a more facetted and dynamic panorama of Mediterranean fisheries, with periods of high development pressure and periods of decline; with areas and resources still in development while others are stabilized or declining, sometimes in the same area or even country.

The best way to validate the conclusions would be to (i) compare with existing historical assessments and/or (ii) to collect the needed complementary information with the view to reduce the existing uncertainties. The first would be faster and cheaper but we already know that the information is scarce and unevenly distributed. The second would take much effort but, while shedding more light on the evolution of the fisheries, it might not lead to more conclusive finding on the state of resources than the quality study undertaken very recently in data-rich European Mediterranean countries (EVOMED 2011).

While no comprehensive review of the conventional assessments available for Mediterranean resources was foreseen in this study, some cross-checks were attempted with existing reviews to get some feeling about the coherence between these global and more analytical approaches.

The GFCM assessments

The GFCM Scientific Advisory Committee compiled the assessments available for the period 1985-1999 for the main Mediterranean resources (**Table 1**, modified from Oliver 2001), based on Virtual Population Analyses (VPA) Length Cohort Analysis (LCA), Yield Per Recruit analyses (Y/R) and, sometimes, on production models and on the use of scientific surveys. The SAC stressed the lack of reliable time series of scientific data but nonetheless detected "a clear growth of overfishing in some selected demersal species and a risk of recruitment overfishing of anchovy and recommended the use of Harvest Control Rules (HCR) and the use of precautionary reference values.

The data show that, at the time of the assessments, more than 60% of the demersal stocks, located in the Northern and Western Mediterranean, were overfished and more than 30 % fully fished. For the small pelagic species 19% are overfished and 38% fully fished, indicating, overall, a relatively less important pressure on the small pelagics.

Table 1: Summary results of the assessments on main demersal and pelagic resources undertaken in the Mediterranean in the period 1989-1995. Modified from Oliver (2000)

Species		State of stocks			
	Underfished	Fully fished	Overfished	?	Total
Merluccius merluccius	1	7	28	0	36
Aristeus antennatus	3	3	6	0	12
Mullus barbatus	-	14	18	0	32
Mullus surmuletus	2	4	2	0	8
Micromesistius poutassou	-	1	3	0	4
Total bottom fish	6 (7%)	29 (31%)	57 (62%)	0	92
Engraulis encrasicolus	-	8	2	4	14
Sardina pilchardus	2	-	2	3	7
Total pelagic fish	2 (10%)	8 (38%)	4 (19%)	7 (33%)	21
TOTAL	8	37	61	7	113
Total %	7%	33%	54%	6%	

Table 2: Overview of the assessments of demersal fish performed and resulting scientific advice to managers, by GFCM Geographical Sub-areas and species

Table 2.1 - Overview of the assessments performed and resulting scientific advice to managers, by GSA and species.

GSA	Species	Data type	Yrs data	Methodology used	Stock status	Fmsy/Fcurr	Fmsy	Proxy
5	*A.antenatus*	Catch, effort, CPUE, Lfreq, Survey	1992-2009	XSA, Y/R	over-exploited	0.540453074	0.334	F0.1
3	*B.boops*	Lfreq	2000-2009	LCA, Y/R	over-exploited	0.677025527	0.61	F0.1
26	*B.boops*	Lfreq	2007-2008	LCA, Y/R	over-exploited	0.54	0.59	F0.1
3	*M.barbatus*	Lfreq	2000-2009	LCA, Y/R	over-exploited	0.810014728	0.55	F0.1
5	*M.barbatus*	Catch, effort, CPUE, Lfreq, Survey	2000-2009	XSA, Y/R	over-exploited	0.4	0.328	F0.1
6	*M.barbatus*	Catch, effort, CPUE, Lfreq, Survey	1998-2009	XSA, Y/R	over-exploited	0.5099	0.389	F0.1
7	*M.barbatus*	Catch, Lfreq	2004-2009	LCA, Y/R	over-exploited	0.57	0.398	F0.1
9	*M.barbatus*	Catch, effort, CPUE	1995-2009	Schaefer, Y/R	over-exploited	0.876712329	0.64	
5	*M.merluccius*	Catch, effort, CPUE, Lfreq, Survey	1980-2009	XSA, Y/R	over-exploited	0.235294118	0.2	F0.1
6	*M.merluccius*	Catch, effort, CPUE, Lfreq, Survey	1995-2009	XSA, Y/R	over-exploited	0.35	0.595	F0.1
7	*M.merluccius*	Catch, CPUE, Lfreq, Survey	1998-2009	XSA, Y/R	over-exploited	0.23	0.201	F0.1
9	*M.merluccius*	Lfreq	2004-2008	LCA, Y/R	over-exploited	0.157142857	0.22	F0.1
18	*M.merluccius*	Lfreq, Survey	2009; 1996-2009	SURBA,LCA,ALADYM Projections	over-exploited	0.350877193	0.2	F0.1
5	*M.surmulettus*	Catch, effort, CPUE, Lfreq, Survey	2000-2009	XSA, Y/R	over-exploited	0.63	0.378	F0.1
5	*N.norvegicus*	Catch, effort, CPUE, Lfreq, Survey	2002-2009	LCA, Y/R	over-exploited	0.661434978	0.295	F0.1
3	*P.bogaraveo*	Lfreq	2005-2007	LCA, Y/R	over-exploited	0.453400504	0.18	F0.1
9	*P.erytrinus*	Catch, Survey	1994-2009; 1990-2009	Y/R	over-exploited	0.358126722	0.13	F0.1
26	*P.erytrinus*	Lfreq	2007-2008	LCA, Y/R	over-exploited	0.52	0.34	F0.1
3	*P.longirostris*	Catch, effort, CPUE	2000-2009	Schaefer	over-exploited	0.255102041		
5	*P.longirostris*	Catch, effort, CPUE, Lfreq, Survey	2001-2009	XSA, Y/R	over-exploited	Unk	Unk	F0.1
6	*P.longirostris*	Catch, effort, CPUE, Lfreq, Survey	2001-2009	XSA, Y/R	over-exploited	0.218978102	0.3	F0.1
9	*P.longirostris*	Catch, Survey	1994-2008; 1990-2008	LCA, Y/R	harvest sustainable	1.166666667	0.7	F0.1
12-16	*P.longirostris*	catch, Lfreq	2007-2009	LCA, Y/R, ANALEN	over-exploited	0.796460177	0.9	F0.1
17	*S.solea*	Catch, effort, CPUE, Lfreq, Survey	2005-2009	XSA, SURBA, LCA, Y/R	over-exploited	0.475409836	0.29	F0.1
26	*S.solea*	Lfreq	2006-2007	LCA, Y/R	over-exploited	0.62	0.41	F0.1
25	*B.boops*	Lfreq	2005-2009	LCA, Y/R	preliminary			
15	*M.barbatus*	Catch, effort, CPUE, Survey	2005-2009; 2002-2009	SURBA	preliminary			
25	*M.barbatus*	Lfreq	2005-2009	LCA, Y/R	preliminary			
3	*M.merluccius*	Catch, effort, CPUE	2000-2009	Schaefer	preliminary			
25	*M.surmulettus*	Lfreq	2005-2009	LCA, Y/R	preliminary			
25	*P.erytrinus*	Lfreq	2005-2009	LCA, Y/R	preliminary			
25	*S.smaris*	Lfreq	2005-2009	LCA, Y/R	preliminary			
6	*C.rubrum*				related work			
9	*N.norvegicus*				related work			

Source GFCM 2011. GFCM: SAC13/2011/Inf. 19:

The more recent compilation of the SAC (GFCM 2011) confirms and strengthens the diagnosis. On the 34 stocks referred to on **Table 2,** it appears that 69% (18/26) of the demersal fish stocks appear overfished and 31% (8/26) in an uncertain state. On the same table 83% (5/6) of the shrimp stocks appear overfished and only one stock (7%) appears to be sustainably fished. The Norway lobsters are not well represented but with the data available, 66% (2/3) of the stocks are overfished and one stock (33%) is unassessed yet. The data on **Table 1** referred mainly to stocks in the western and northern Mediterranean. Table 2 includes some stock from GSAs belonging to the Levant area in the East.

The EVOMED study

Additional and relevant information has also been provides by the recent historical study of the European Commission European countries' demersal fisheries (EVOMED 2011). This major compilation used historical data on the fleets and the resources as well as interviews of fishermen, to make some statements on the evolution of the fisheries parameters: fleet size and capacity, vessel power, catches volume and composition, abundance, discards etc.

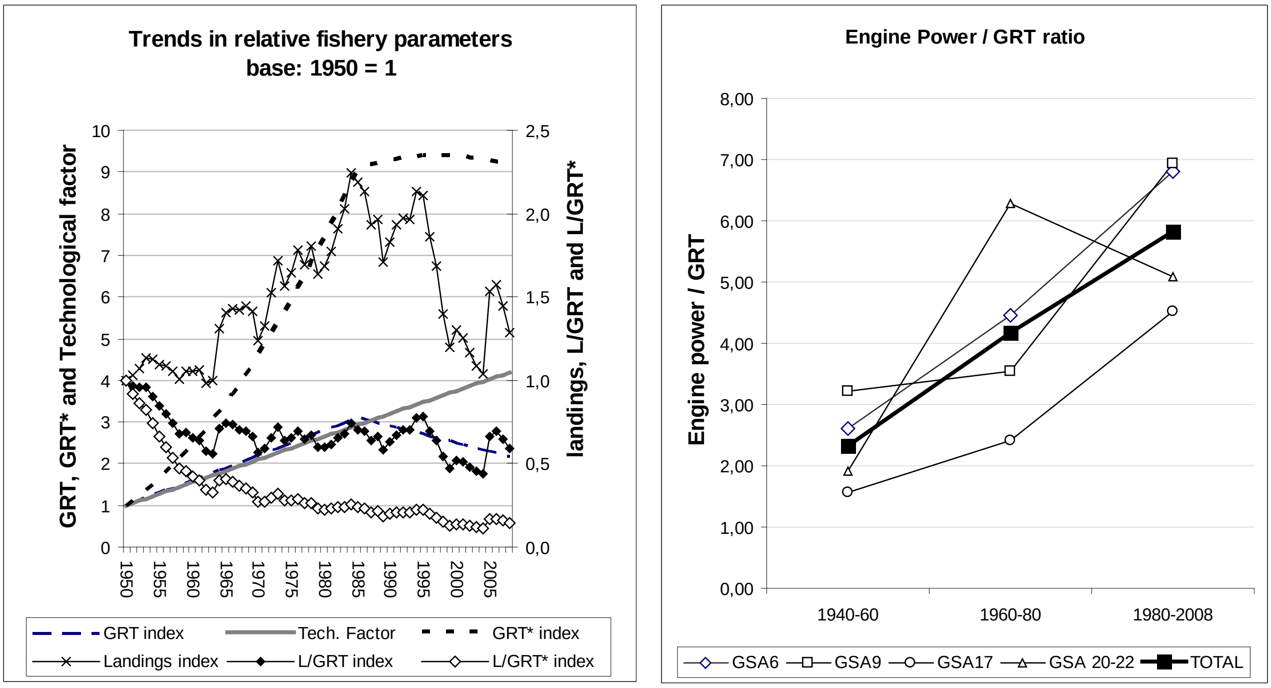
The information provided is much too abundant and complex to be summarized here. The following conclusions referring to the northern and western Mediterranean bottom fisheries only, during a period extending from the 1950s to today, are however of some interest for the purpose of this section:

- There has been a notable increase over time of the number of fishing vessels, their size and their engine power. The main and most common and homogenous factor of growth in fishing capacity has been the vessels average engine power which grew up to 5-8 times between the 1950s and the present. Recent mandatory vessel power data (as formally reported) seems to be below reality (as transpiring from interviews). In addition, the present vessels have progressively improved the on-board technology (communication, positioning, gear operation, working conditions, processing) increasing the relative efficiency of every unit of Gross Registered Tonnage (GRT) or power put to work. Because of the technology factor, fishing capacity increases faster than GRT or HP. In addition, the fishing range has progressively increased from the early coastal areas and shelf to deeper waters down to 500 and even 800 meters. Since 1980, the number of vessels have significantly decreased *as a result of different national and European decommissioning programmes but it is unclear whether this decrease in fishing capacity in the last 20 years has* *been accompanied by a decrease in fishing power and fishing mortality on the stocks because engine power may be underestimated (under-reported) in many countries region and fishing technology has much improved over the last decades* (EVOMED 2011).

- Catches have increased for 3 decades. They peaked up and started decreasing in the mid 1980s and seem to have decrease since then, more than interviewed fishers remember. Possible biases affecting their perceptions include: (i) changes in discard rate throughout the years, (ii) changes in mesh size and selectivity; (iii) increased fishing power of trawlers; and (iv) change of fishing grounds (deeper) and related changes in fishing gear.
- Because of the difficulty encountered in standardizing the fishing pressure index, no long-term abundance trends were produced. Interviews did not yield much better information as fishermen's perception of abundance is likely confused by changes in gear, depth fished, vessel and gear types and sizes, fishing power, discarding practices, and types of fish boxes used for landing.
- Nonetheless, the analysis indicates that over time, catches of some taxonomic groups declined. Some bottom fish were among the most affected, particularly sharks and rays. Extreme decreases in abundance of species such as *Mustelus* spp., *Squatina* spp., *Squalus* spp., *Oxinotus centrina, Scyliorhinus canicula,* and *Raja clavata* have been reported practically everywhere. *Mustelus sp., Squalus* spp. and *Squatina* spp have apparently totally disappeared from some areas. The phenomenon started after WWII in the northern Mediterranean and more recently in the East and South. The abundance is apparently well below 10% of what it was in the 1950s in many areas. *Mustelus sp.* totally disappeared in the northern Aegean Sea river mouths. All specialised sharks' fisheries, using specific gears, have collapsed after 1960. The sturgeon *Acipenser* sp. disappeared from the Adriatic since 1966. Pelagic fisheries are not covered by the EVOMED analysis but decreases also in the abundance of *S. scomber* and *E. encrasicolus* has been mentioned in the Adriatic. On the contrary, increases of prey species such as *N. norvegicus* and *S. mantis* were mentioned in the Adriatic. Among bottom fish species, red mullets appear also among most affected. The decrease in abundance is indirectly confirmed (without data unfortunately) by Bas Pereid (2006: 379) who notes that, for quite some time *the increase in value of the fish more than compensating for the decline in abundance.*
- In terms of other environmental impacts, the study reports on the fishermen's perception of a significant decrease in abundance of benthic species bycatch such as: sponges, gastropods, tunicates, corals, and bivalves, possibly due, at least in part, to progressive increase of net mesh sizes and selectivity and in part to ground "cleaning" by repeated intense trawling activity. Sightings of cetaceans, seals and sea turtles are also reported as having significantly decreased. Monk seal sightings and incidental catch also disappeared as well as sturgeon. However, in increase of dolphin sightings has been noted in the Ligurian Sea as well as Northern and Central Tyrrhenian Sea (GSA 9) during the last ten years.
- Discards appears to have been very low and limited to damaged individuals before the 1960s. They increased with fisheries development due to market problems as landings as well as imports increased. When "good" species are present on the market, the less appreciated ones end-up discarded for want of a viable market and following the introduction of minimum landing sizes. When landed, they often end-up labeled as "unidentified". Species discarded include small hakes, red mullet, horse mackerels and rays.

The EVOMED study did not attempt to assess state of resources or potentials. Nonetheless, the scenario described by this comprehensive study for developed Mediterranean countries fits the general pattern described for global fisheries development (e.g. by Garcia and Newton 1997) and it could be interesting to look at its implications, albeit in a very crude manner. The study raises the issue of the evolution of the technological factor (or technological creep) in shaping the evolution of fishing capacity and distorting the perception of fisheries performances. Fitzpatrick (1996) estimated the technological improvement factor resulting from progressive modernization of fishing vessels (about 5% per year). The data were used by Garcia and Newton (op. cit.) to calculate a crude global technological factor and generate a global bioeconomic production model. Assuming a similar technological factor applied also to the efficient Mediterranean fisheries of Europe, the trends in the aggregate system of bottom fisheries of Spain, Italy and Greece are portrayed in **Figure 27** (left) in which all values have been standardized to their value in 1950 to facilitate trends comparisons.

Figure 27: Left: Simulation of the evolution of the bottom fishery system in Catalonia, Italy and Greece



Source: Landings from Fishstat. GRT from EVOMED 2011 in 1950, 1985 and 2008, interpolated. Technological factor from Garcia and Newton 1997). GRT* = GRT corrected by the technological factor. All variables are standardized to their value in 1950. Right: Evolution of the power/size ratio in GFCM GSAs. Data EVOMED 2011.

Figure 27 shows that the landing index reported for bottom fish fisheries selected categories (ISSCAAP categories 31, 32, 33, 34, 38, 39, 43, 45, and 57) by Spain, Italy and Greece, raised until the 1980-1990 and declined after that period, at about the same rate, until 2008. The total GRT estimated by EVOMED (Part II, section 4.1)[12] for Catalonia, Italy and Greece is 120,000 tonnes in 1950, 337,500 in 1980 and 194,500 in 2008. The data for the intermediate years have been linearly interpolated to generate a complete time series. The picture also shows the increase in the technological factor and the evolution of the GRT* when corrected by this factor. The product of the fleet GRT by the technological factor (which can be considered as an index of fishing capacity adjusted for the rise of the fishing vessel power), increases until the mid-1980s and then remains at that level despite a decrease in the volume of the fleet. The shape of that vector would support the EVOMED study which indicates that: *Although total real engine power and capacity are probably higher than what is reported in official sources, it is likely that the big surge in fishing effort and capacity of the 1960sand 1970s has been stalled and that current installed engine power and capacity are similar to the values of the first half of the 1980s.*

The landings per unit of GRT can be used as a very raw index of nominal abundance of the resource aggregates. The figure shows a decrease of that ratio from 1 in 1950 to about 0.55 in the last decade. Considering that the stock was not virgin in 1950, this 50% decrease is already substantial and, in a production model, would bring the present fishing pressure close to the effort corresponding to the Maximum Sustainable Yield level. However, this assertion cannot be sustained as it assumes that a unit of GRT in 1959 has the same efficiency and impact on the stocks than a unit in 2008, which is obviously not the case. The landing /unit of GRT*, taken as an index of abundance corrected for technological improvement in fishing power decreases much more rapidly and is about 0,14 in the last decade, well below the 0,55 index found above and well below the abundance that would correspond to MSY. This elaboration does not account for the fact that the horsepower/GRT ratio (**Figure 26** right) has also increased with time and therefore that the total engine power of the fleets (a key factor in trawl fisheries) has increased three times faster than GRT and is even now

[12] The data were either extracted from the text, when available, of from the figures.

most probably underestimated by official records (EVOMED 2011: section 4.1.4). The trend in corrected capacity between 1950 and 2008, as reflected in **Figure 26** (left) could therefore be underestimated.

This elaboration is very crude. It averages the trends in 3 different countries. It divides the total landings (with all the deficiencies they may have) by a global measure of capacity that mixes artisanal fisheries in more coastal areas with semi-industrial fisheries in deeper waters. It also aggregates trends in a mosaic of resources belonging to two different "ecosystems", the shelf and the slope, which contributed different proportions of the total at different times.

It is therefore too coarse for management purposes except perhaps for raising further the policy-makers awareness, illustrating the huge increase in fishing pressure that has affected the fishery resources of the northern Mediterranean since 1950. We do not have an equivalent study for the southern and eastern Mediterranean. The intense development started probably later in these areas but it also probably progresses faster as good technologies and fishing practices had already been tested in the northern Mediterranean and could easily be obtained from the market. Indeed the existence on time series with no identifiable trend from the 1950s tends to indicate that these areas may have reached their maximum production before the beginning of the time series and their state can only be determined by conventional assessments (which, by the way, indicate that resources are often overfished).

VII. Summary conclusions

The purpose of this study is to provide the Mediterranean Blue Plan project with a synoptic view of the state of fisheries development in the Mediterranean and therefore indirectly of the likely state of the underlying resources. The study is particularly timely as the concern has been growing in international instances about the state of the resources and the GFCM has been stressing repeatedly the concerns about the resources (based on scientific assessments) and the need to start seriously regulating capacity, effort and catches.

The study analyses the state of the fisheries looking at trends in landings and landing growth rates for the key resources of the Mediterranean. It does so at the level of the Mediterranean Sea, the different GFCM statistical areas, and the countries (Home Areas). It could not be done at the scale of the management areas recently defined by the GFCM (the GSAs) because the corresponding time series are not yet available (at least publicly) for that purpose.

The data is taken from the FAO Fishstat databases for the FAO Fishing Area 37 –Mediterranean and Black Sea 1950-2008 (taking out the Black Sea data) and the GFCM data set for 1970-2008. From this data, key groups of species were selected using the ISSCAAP categories to reflect the fisheries on bottom fish (on the shelf and the slope) as well as small pelagic species. Sharks and rays, lobsters, shrimps and prawns as well as squids, cuttlefish and octopus were included. Tunas and tuna-like species as well as species such as coral, turtles, cetaceans, tunicates, etc. were not analyzed.

The methodology rests on the use of the fishery development cycle (*sensu* Garcia 2009) already used for the World Bank review of the state of world fisheries. This cycle analyses the landings in terms of progression in the development cycle from Development to Maturity and eventually to Senescence and, sometimes, to Recovery. The main assumption is that the trends in landings, despite all the alleged and real problems with their quality, reflects mainly the impact of the fishing fleets, particularly during the main fishery development phase, observed between 1960 and 1990 in most of the world fisheries. The method compares the landing variable with the Long Term Maximum Average Yield (LTMAY) to identify the periods of growth (Development), stagnation (Maturity) and decline (Senescence). The numerous graphs produced with the time series are analyzed one by one and then summarized in a synoptic representation that gives a global perception of the development processes, allowing fruitful comparisons of the empirical between resources, areas and countries, looking for contrasts or coherence and overall diagnosis.

At Mediterranean-wide level, the data show an overall stagnation for 2.5 decades of the aggregated production (about 800,000 tonnes). The pelagic low value species show the same pattern (about 500,000 tonnes) while the bottom high value fishes increase until 1990 to close to 300,000 tonnes and decline until 2008.

At regional level, the 8 GFCM sub-areas show different behaviour. The resources increase in some areas, stagnate in others and decrease still in others. There are some general patterns:

3) The fisheries appear generally in more advanced stage of development (and unfortunately of senescence) in the western and northern Mediterranean than in its southern and eastern parts.

4) In general, pelagics resources appear less pressurized than demersal ones, in coherence with the higher economic value of the second. Also, among the high value resources, lobsters appear more pressurized and less able to sustain maturity situations. Similarly, sharks and rays appear extremely pressurized for the entire period, probably with a collapse of all targeted fisheries in the 1960 and repeated cycles of development-maturity-senescence. Shrimp resources are in a better shape and are still increasing, and perhaps have reached their maximum. The same seem to be happening with cephalopods. For all these resources the entry in "Maturity" and senescence occurs earlier in the North and West and maturity stages tend to be shorter also in these regions.

At national level, the same general pattern prevails with some intriguing differences. The overall trend in development pressure from West to East is clear. However, the pelagics seem to have started reaching maturity earlier than the demersals even if the latter have recently reached Senescence for a high percentage of country fisheries.

Although the study was not planned to make a full comparative analysis of its results with the more conventional assessments made in the ambit of GFCM, a few comparisons with recent reviews indicate a general coherence (e.g. in the degree of overfishing in demersal and pelagic stocks) and show evidence that the landing trends analysis reflect the underlying fisheries dynamics and their interaction with the resources.

This indicates that the approach can be useful, particularly but not only, where more scientific observations are scarce. Having a more complete coverage in time and space, used with caveat, it can provide a useful backdrop to more sophisticated assessments. In areas with limited scientific background, it can be used to promote a dialogue between the scientists, the policy-makers and the industry stakeholders with the view to better understand the fisheries sector past history, and present likely state.

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Annex 1 - The Fishery Development Cycle[13]

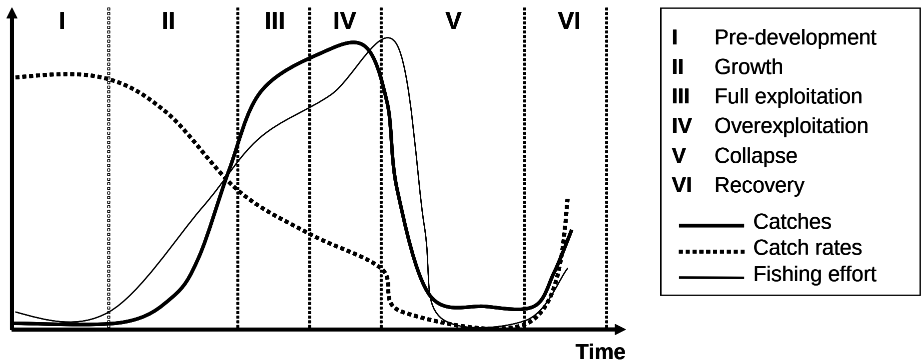
Business development "cycles"

Since the 18th century, the oscillations affecting business development have been noted and discussed e.g. by Malthus (1766-1834), Ricardo (1772-1823) or Marx (1818-1883) (R. Arnason, pers. Comm.). In 1860, the French Economist Clement Juglar (1819-1905) described them dividing them into 4 phases: expansion, crisis, recession and recovery. A comprehensive treatment of the subject was given by Schumpeter (1939). These fluctuations are still often referred to as business or economic "cycles" even though there was and still is controversy about their real nature. Are they entirely random? Are they provoked _on an otherwise random fluctuation_ by "shocks" corresponding for example to changes in policy, credit availability, technological innovations, etc. Are some periodicities deterministic and predictable as believed by Kondratieff (1892-1938) and Marchetti (1987)[14]? Independently of their nature and underlying mechanisms, there seem to be currently a common understanding among business development specialists that businesses develop with fluctuations of their economic activity (sometimes referred to as "booms and busts") around their long term development trend. These involve shifts over time between: (i) an initiation phase of exploration and invention; (ii) a growth or prosperity phase showing a relatively rapid growth of investments and output; (iii) a phase of relative stagnation or decline during which the business experiences contraction and recession and, hopefully, (iv) a phase of recovery.

The single-fishery development cycle

Fluctuations are certainly a central characteristic of fisheries resources and fisheries activities and they can be observed at stock, sector, region or global levels. At single fishery level, these phases have been identified: initial low production, followed by fast growth, fluctuating stagnation, and, sometimes, decline and collapse (Larkin and Wilimovski 1973; Csirke and Sharp 1984).

Annex 1 Figure 1: Development cycle of a single stock fishery



Note: Redrawn from Csirke and Sharp (1984). Courtesy FAO

These may originate in government policy changes or private sector decisions to capture new opportunities. In addition fisheries resources and the outcome of fishing and management have clearly been affected by ocean-atmosphere coupled oscillations such as the El Niño Southern Oscillation (ENSO) in the equatorial Pacific, the North Atlantic Oscillation (Marshall et al. 2001, Stentseth et al. 2003, Wang & Fiedler 2006) as well as by the increase in the heat content of the world ocean (Levitus et al. 2000). Biological effects

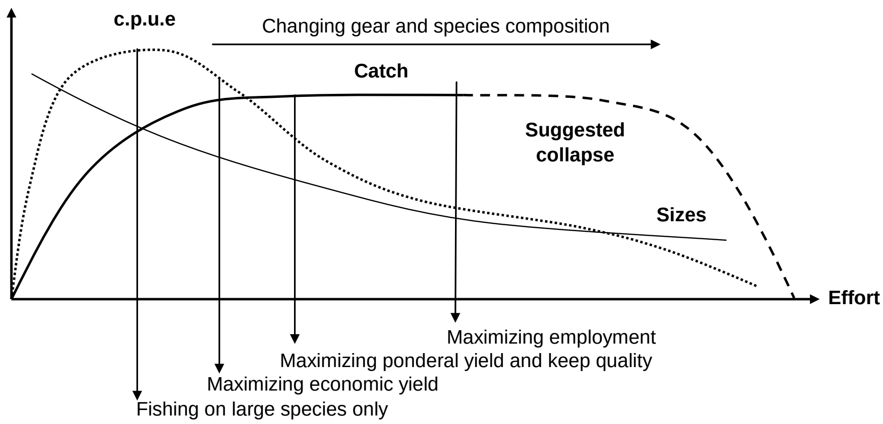
[13] The text in ingrally reproduced from Garcia (2009) with the Permission of the World Bank.

[14] Marchetti (1987)[14] has drawn attention on the existence of logistic growth patterns in number of economic and social fields such as energy consumption, the use of horsepower, the appearance of basic innovations and key scientific discoveries, bank failures, homicides, etc. These fields experience growth and declines as "epidemics" which, according to Marchetti, justifies the use of biological logistic models to describe and forecast such complex socioeconomic developments

attributed to quasi periodic decadal-scale climatic fluctuations have been described, sometimes in synchrony across space and species, sometimes in phase opposition. The latter appear sometimes in synchrony across space and species, and sometimes in phase opposition (Glantz and Thompson 1981; Csirke and Sharp 1984; Klyashtorin 1998, 2001; Chavez et al. 2003). Furthermore, violent events such as civil and other wars send shocks through the entire economic system and disturb the "classical" logistic development pattern. Through delayed dynamics response of the stock and of industry, these perturbations have generated fluctuations in the outputs of the sector, in both quantity and quality[15]. Klyashtorin has even used the cycles identified to predict catches and their species composition in the future. In analyzing fishery production trends, we should therefore expect to see, in the landings data, a general development pattern for the period 1950-2006, reflecting essentially investments in the production chain and increasing consumption. This long-term trend should be perturbed by higher frequency fluctuations reflecting co-generated by natural and socio-economic drivers as well as sampling noise.

At the higher levels of aggregation of a sub-sector, country, region, or ecosystem, the development pattern may differ slightly because the differences in the single fisheries developments and sequential overfishing may generate smoother aggregated trajectories and a flatter-topped pattern as the one described by Welcomme (2001) for large inland water bodies.

Annex 1 Figure 2: Development cycle for aggregated fisheries and related management objectives.



Note: Redrawn from Welcomme (2001). Courtesy FAO-Fishing News Books.

Under this model, the sequential overfishing (if it occurs) is hidden in the changing composition of landings. The simultaneous collapse of all fisheries appears unlikely, unless the environment is also destroyed as in the Aral Sea or severely compromised as in the Black Sea. However, a severe drop in production is to be expected when all potential resources in the area are overexploited and the ecosystem system has reached the limits of its adaptive capacity.

The conventional single fishery development model or cycle (as described for instance by Csirke and Sharp (1984) can be decomposed in phases as follows:

1) Pre-development: also referred to as under-development or exploration phase is characterized by a very low fishing pressure, no or limited market, no or ill-adapted technology. Biomass is close to virgin levels. Catch rates bear little or no relation to those that a targeted fishery could obtain. Innovative fishers look for opportunities. The stocks are considered as "underexploited".

2) Growth. Or development. It has sometimes been subdivided into: (i): an initial growth, involving only a few pioneers, innovators and risk takers, and (ii) a full or exponential growth when the innovation spreads rapidly to new entrants attracted by the high initial catch rates and profits. Growth can happen in a series

[15] For instance in the relative proportions of small pelagic and demersal fish.

of successive bursts separated by stabilization periods (Larkin and Wilimovski 1973). It is triggered by development clues such as discovery of a new resource, invention or adoption of more efficient gear or fishing practices, increasing boat range (through improved motorisation or catch preservation techniques), and opening of a new market. Specific infrastructures are developed and economic incentives provided that attract new entrants. The development brakes necessary to avoid "overshooting" are rarely put in place. The stocks are considered as "intensively exploited".

3) Full exploitation. It is generally difficult to know when a fishery has reached full exploitation before that stage has been passed. In the Law of the Sea Convention, full exploitation meant extracting the Maximum Sustainable Yield (MSY). Since the adoption of the 1995 UN Fish Stocks Agreement[16], MSY is to be considered as a limit and not a target. Full exploitation should therefore stop before. During that phase, abundance decreases further. The less efficient operators may be forced out of the fishery. In multispecies fisheries, some may transfer part of their efforts to some bycatch or other species acceptable to the consumer, looking for new markets. The periods of stability are ultimately characterized by a dominating set of harvesting techniques. If they were well managed, stocks (and catch rates) would stabilize and only oscillate around their mean, driven by climatic conditions. Indeed, in the general business cycle, this should be the stabilization phase. In practice, this phase has tended to be ephemeral as the fishery moves into the next phase. The stocks are considered as "fully exploited".

4) Overexploitation. A phase apparently described only in fisheries although overdevelopment and overinvestment[17] exist in the general business theory. The fishing pressure is higher that the level corresponding to MSY. The phase can be more or less rapidly depending on fishing pressure build-up and the species life parameters. Overexploitation (or overfishing) may happen while catches are still higher than MSY ("overshooting") because of the delay in the stocks response to fishing. Eventually catches will decline (and catch rates plummet) as the stock finally adjusts to the pressure. When overexploitation meets with poor climatic conditions, the collapse can be fairly rapid[18]. Under overexploitation regime, the stocks are (or soon become) "overfished". When overexploitation is severe and biomass have been reduced well below the MSY level, the stocks are labelled as "depleted".

5) Collapse. Originally, this term intended to describe a situation of sudden and deep decrease of abundance and catches, usually immediately followed by a sudden reduction of fishing effort as fishing becomes highly unprofitable. This usually happens when overexploitation meets with poor climatic conditions and leads important economic losses and intense social stress. The stocks are also considered depleted. It has been considered for a long time that excessive fishing could not extinguish target species. It is now recognized that some groups (e.g. the elasmobranchs) are at high risk. Recent works have shown that they might have led to extinction of local populations stocks (Dulvy et al 2004). Unfortunately, as those are not directly exploited, they may not be assessed and move "under the radar".

6) Recovery: hopefully, following the drastic reduction of fishing pressure (outright bans may be needed) and assisted by favourable climatic conditions, the stock may rebuild progressively its biomass, provide its habitat has not been strongly damaged (Francis et al. 2007). Many depleted stocks have been simply "left alone", often still exploited as bycatch. In many other cases more or less formal recovery plans have been put in place with varying degrees of success (Caddy and Agnew 2004). The World Summit on Sustainable Development (WSSD) has adopted in 2002 a plan that foresees the recovery of the world depleted stocks by in 2015. The stocks are labelled as recovering.

Ideally, overfishing and collapse should only happen in unmanaged fisheries, with no or poor control on access to the fishery and extraction rates. In practice, overfishing is rampant and collapses happen not that rare, underlining the reform of fisheries development and management policies.

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[16] Annex II.7 of UN Fish Stocks Agreement provides that, "*the fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points*".

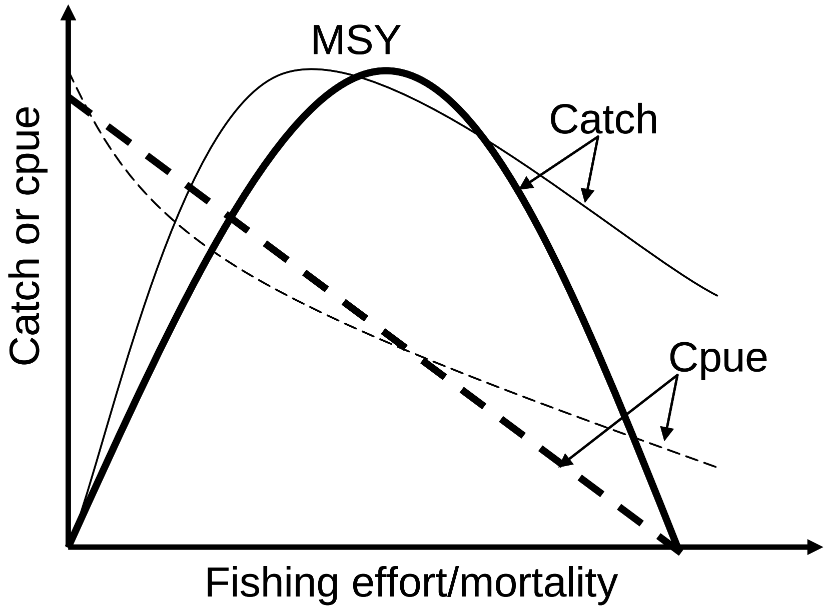
[17] <u>Overdevelopment</u> is a process by which natural resources are impacted by development at a rate significantly harmful to the ecosystem. <u>Overinvestment</u> is the practice of investing more into an asset than what that asset is worth on the open market (Wikipedia)

[18] Examples include the Peruvian anchoveta and the Canadian cod.

Annex 2 - Production modelling in complex fishery systems

In fisheries science, the historical development of a fishery through its different development phases is often represented using the simple logistic biological production model (or surplus yield model) adapted to fisheries by Schaefer (1954). This model assumes a logistic saturation process of the ecological volume available to the resource -the so-called "carrying capacity" of its habitat. In other words, the intrinsic growth rate of the population tends to zero as the population size approaches the carrying capacity. From the onset of the population growth to the saturation of its habitat, the instantaneous variation of population size increases from zero to a maximum value, and then decreases to zero as the saturation is reached. In the logistic model, this self-limitation of population growth by population size is described by a parabolic relationship (the Schaefer model), but many other "unimodal" curve types are suitable. This global model has been applied to fisheries by subtracting the instantaneous catch from the population production. It also assumes a parabolic relation between stock biomass and productivity or equilibrium catch. It assumes also a negative linear relation between fishing effort and abundance and a parabolic relation between catch and fishing effort.

Annex 2 Figure 1: Production models of Gulland (thick lines) and Fox (thin lines)



Recognizing that in real situations, the conditions required for a perfectly parabolic model were rarely fulfilled, various models allowing departures from the symmetric parabola were elaborated e.g. by Fox, Pella and Tomlinson, and many others. These variants allow more flat-topped representations to be used, reflecting a stronger resilience of the resources mix to exploitation than the one assumed by the Schaefer model. Even when dealing with a single stock and a single-gear fishery, the assumptions of homogeneity (of the stock and of the fleets), constancy of the relations (between effort and fishing mortality or between catch rates and abundance), equilibrium and reversibility of trajectories, implicit in the model, are rarely if ever fulfilled in reality.

In fisheries, the extension of the application of such models from single populations exploited by homogenous fisheries to multispecies multigears fisheries, emerged among biologists in management and scientific literature in the 1970s, in the Northern hemisphere (Garrod, 1973; Brown et al. 1976; National Research Council, 1977), and it has been of particular concern in the tropics where multispecies-multigears fisheries are the rule, both in marine and freshwater systems (Gulland, 1972; Henderson, Ryder and Kudhongania 1973; Pope 1979; Kirkwood 1982). An interesting historical record reflecting that concern can be found in FAO (1978), a report which is also a good source of references on early works in this area.

Both Gulland (1972) and FAO (1978) describe quite well the essence of the problem of applying a production model to a composite fishery, in relation to the Thai trawl fishery sector and particularly the problem caused by the geographical expansion of the fishery with time (changing underlying biomass and modifying fishery parameters) and the changes in species composition (due to the geographical expansion as well as changes in the ecosystem under fishing pressure. fishing intensity). While the fundamental relations structuring the production model probably still apply, the generality of the "pure" model is lost as the exact parameters of the relations, their shape, and the type of reaction one can expect from the system are unpredictable (Kirkwood, 1982). The few developments towards a new generation of production models for such situations (e.g. by Pope 1979) confirmed the need to use them and their conclusions with caution (Kirkwood, 1982; Holt 2009).

Nonetheless, for want of a better alternative, and assuming that, used with cautious they could still provide useful management guidance, these models have been used at aggregated level, for the assessment of multispecies resources in the tropics: in Thailand (Gulland 1972; Pope 1979; Boonyobol and Pramokchutima 1984); the Philippines (Dazell et al. 1987); Jamaica reefs (Munro 1978); African inland lakes (Henderson and Welcome 1974); tropical rivers (Welcomme 1976); East African marine fisheries (Gulland 1979); the Mediterranean (Garcia 1984); and the whole world (Garcia and Newton 1997; The World Bank 2009). It must be stressed that most of these applications were not intended for operational decision-making but as metaphors of the state of the fisheries or the sector, as evidence that the resources were being significantly affected, and as support for strategic recommendations to exert stricter control on extraction rates; a foregone conclusion in many cases.

Kirkwood's advice was to use them but empirically, conscious of the violations and possible consequences, not forcing the emerging relation to a convenient conventional form, particularly to the unlikely perfect parabola. Indeed, in inland fisheries (Welcomme 2001), it seems that the use of the multispecies production model has been more pragmatic and more realistic than in the marine fisheries, recognizing its no-parabolic shape and the numerous changes in the ecosystem as fishing stress increased.

This discussion is extremely relevant to our consideration of landings trends in this study. Like the aggregated fishery development model used in this study, the simple production model has been applied because of its limited data requirements _at the price, however, of a very limited explanatory and predictive power. Facing explicitly these difficulties when assessing the Gulf of Thailand fisheries, Gulland (1972) argued that "*the surplus-yield model may be the only usable technique at present for the analysis of the complex fishery under study. It can establish the main dynamic properties of the fishery and can indicate the first steps required to regulate it for the management purposes which are urgently needed at present…reducing the total amount of fishing. Once this is done and the fishery as a whole is in a more healthy state, further analysis may show that additional management action may be needed, more specifically directed towards one or other species group. However, until this first step, to reduce overall effort, is taken…the combined analysis is perfectly adequate.*

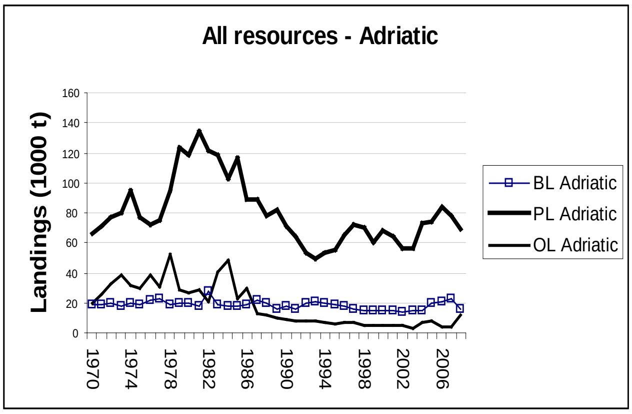
Gulland recognized the imperfection of the model and the resulting uncertainty. With the rigor and pragmatism that has always characterized his work, he suggested precautionary action: i.e. to cut down on effort as soon as possible (even if the scientific basis for the action was not perfect) and to follow with adaptive management. The situation Gulland faced in Thailand at that time is still the situation faced today in many developing countries, and not only there.

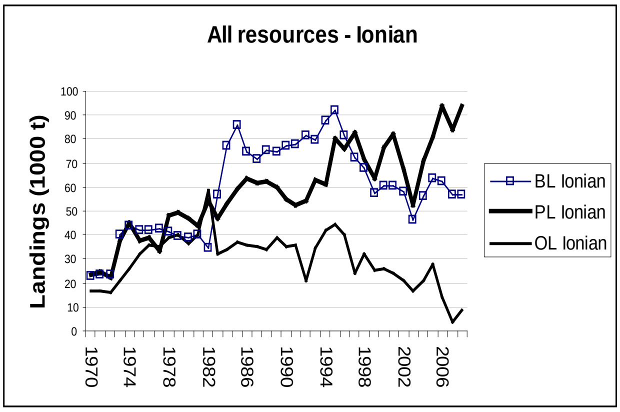
The global application of the bioeconomic production model by Garcia and Newton (1997) and more recently in the World Bank report (2009) to a global assessment of the State of fisheries, rest on the same rationale Gulland so nicely expressed 35 years ago, simply because the capacity to deal with the problem at that level of aggregation has not really improved. The urgency remains to reduce overall fishing pressure. The arguments brought about by these two studies despite their limitation _in addition to confirming stocks depletion_ is the huge amounts of wealth lost through subsidies and lost rents.

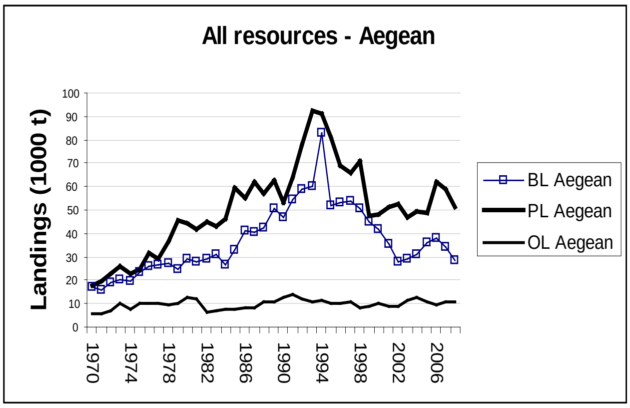
The application of the aggregated development model has been made with a similar rationale in mind.

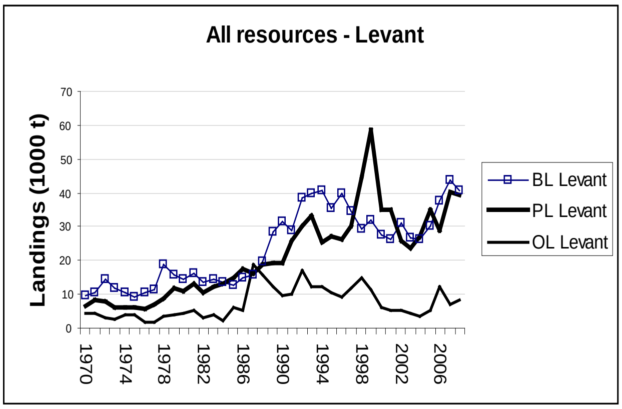
Annex 3 - Development cycles

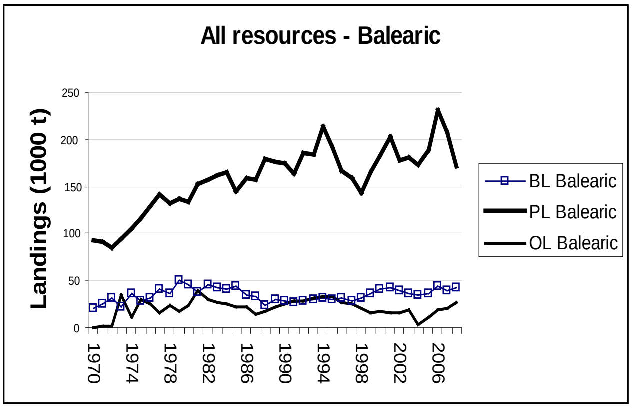
Plate 1: Regional trends in landings categories. Comparative evolution in GFCM sub-areas

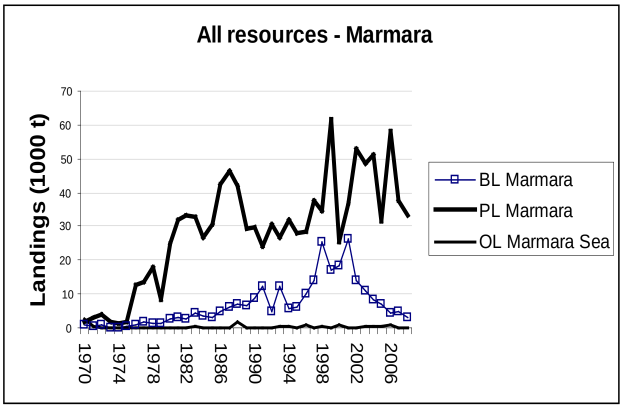


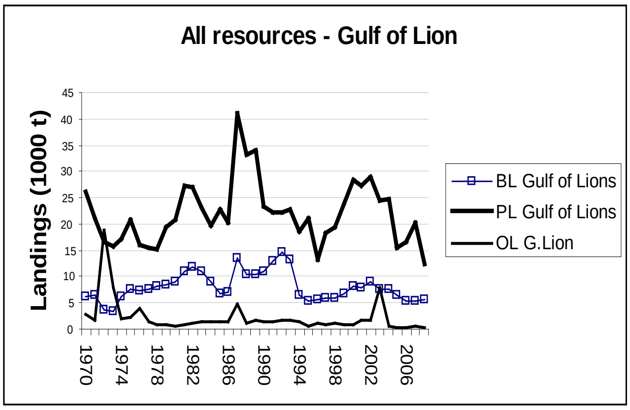












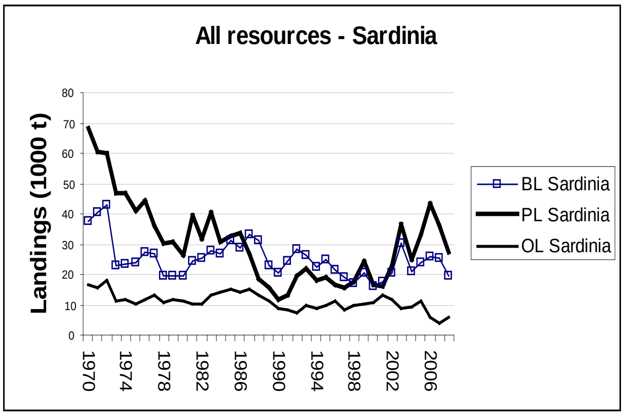


Plate 2A: Total Fish. Development patterns in GFCM sub-areas 1970-2008

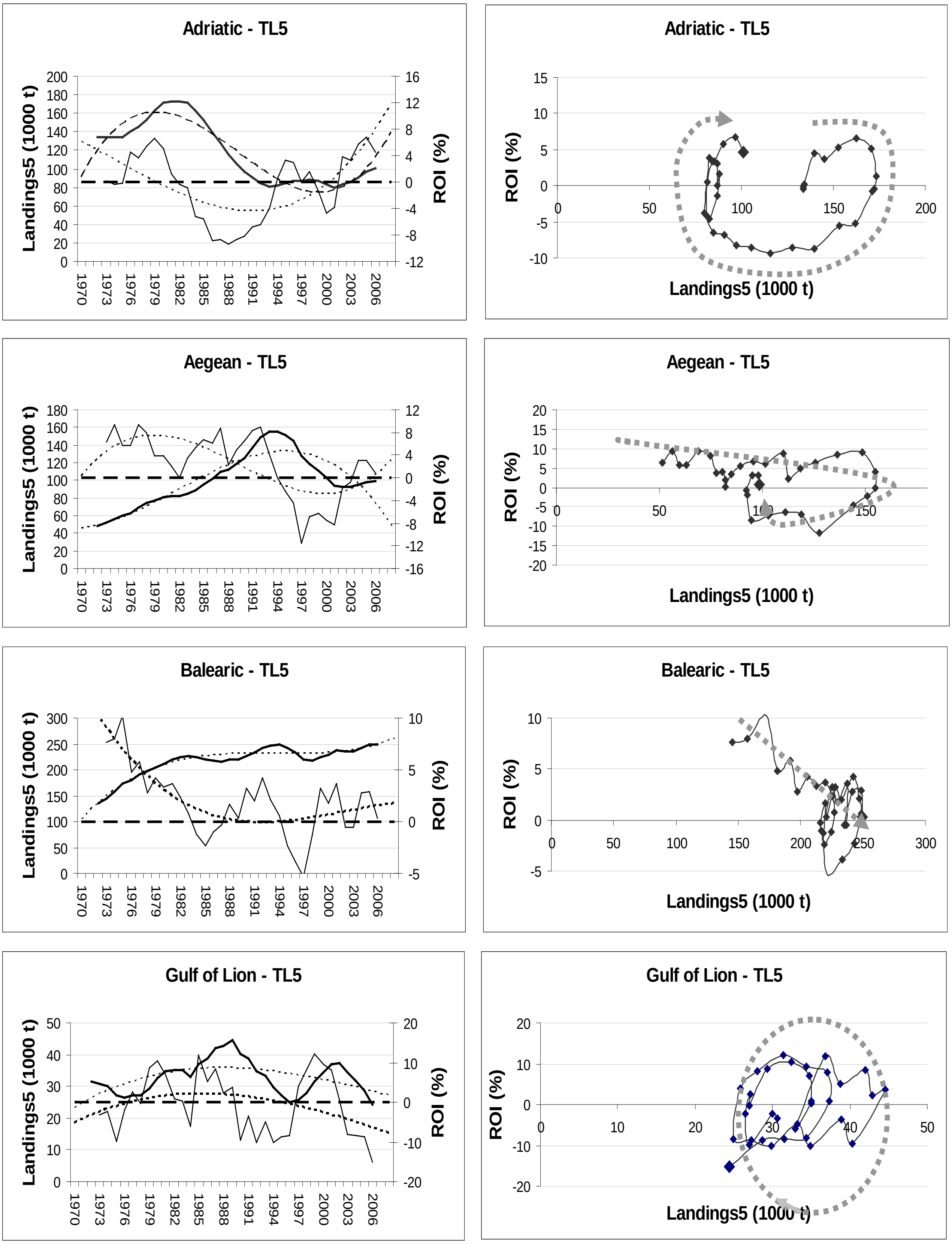
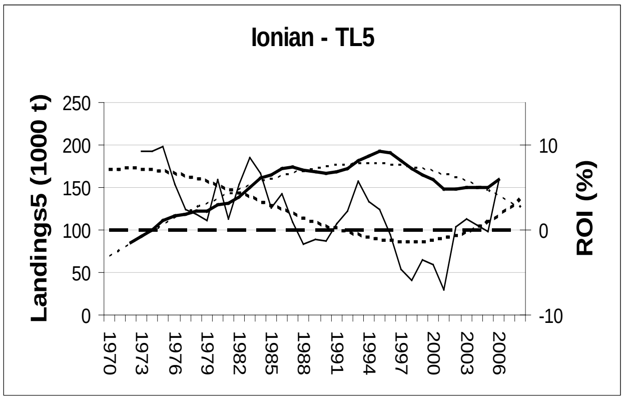
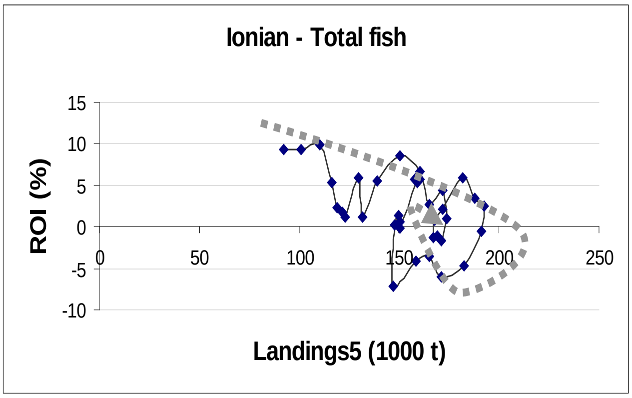
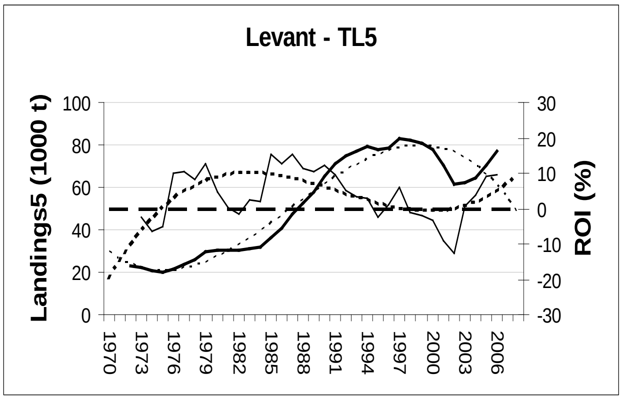
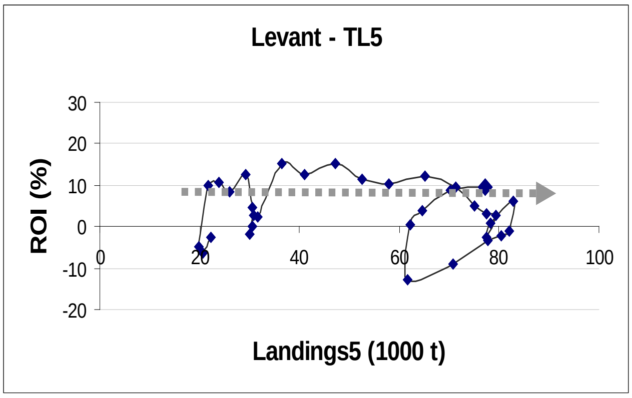


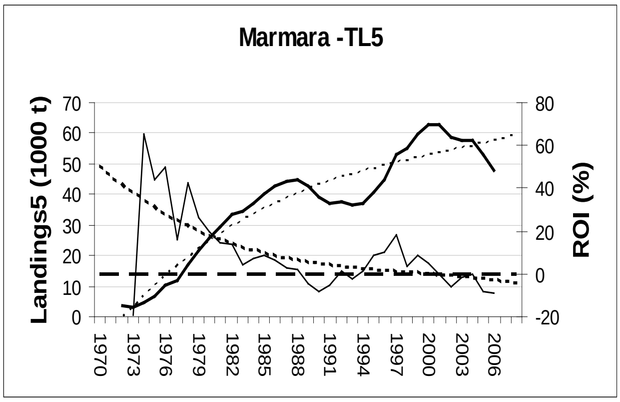
Plate 2B: Total Fish. Development patterns in GFCM sub-areas 1970-2008

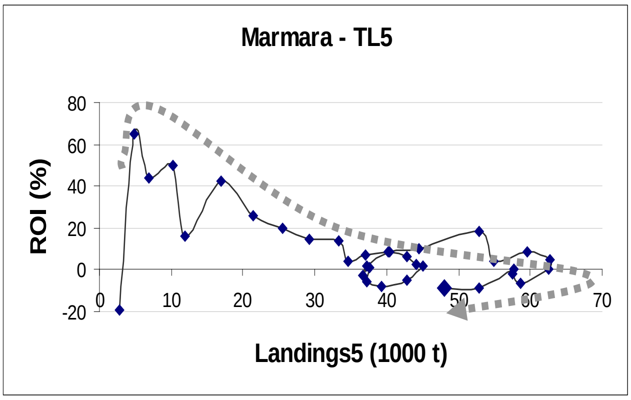


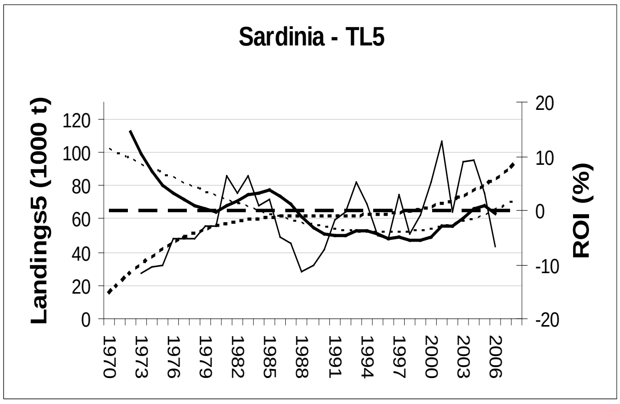












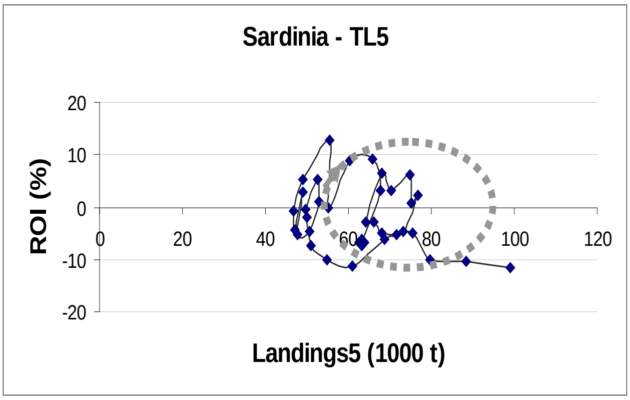
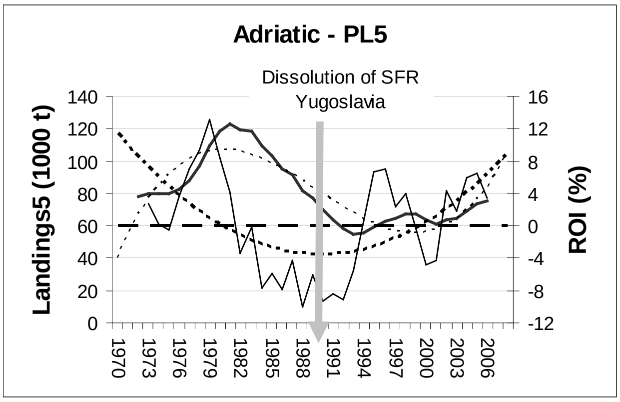
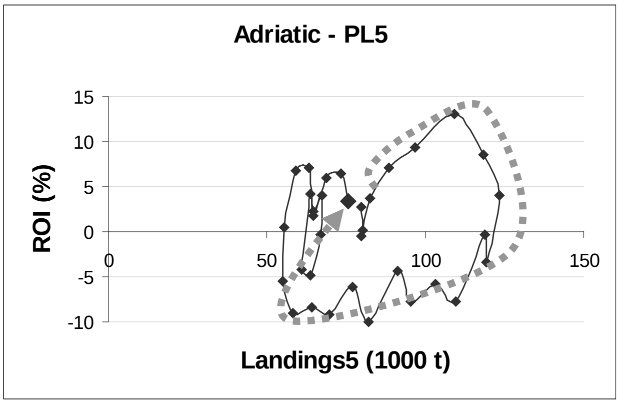
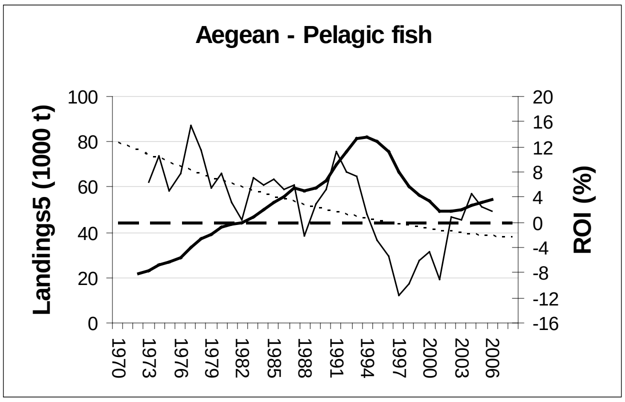
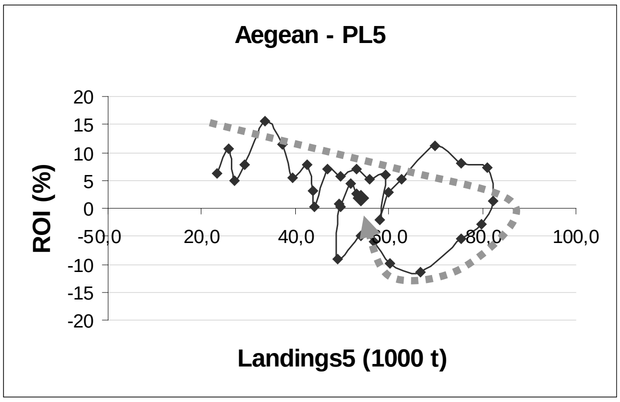


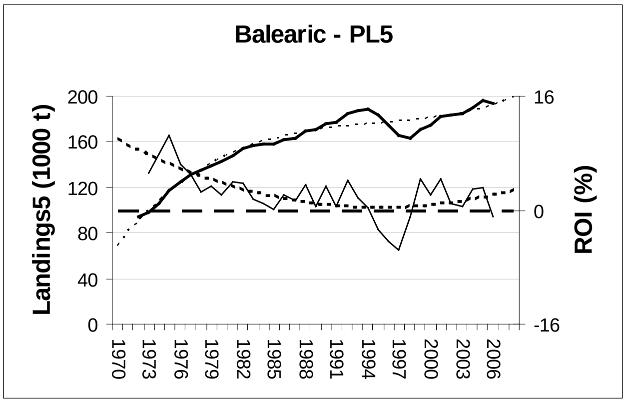
Plate 3A: Pelagic Fish. Development patterns in GFCM sub-areas 1970-2008

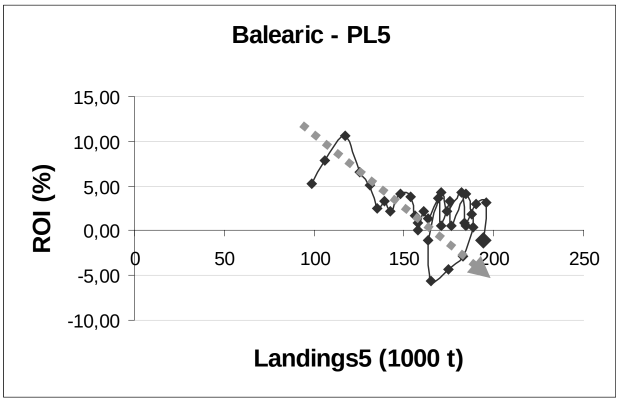


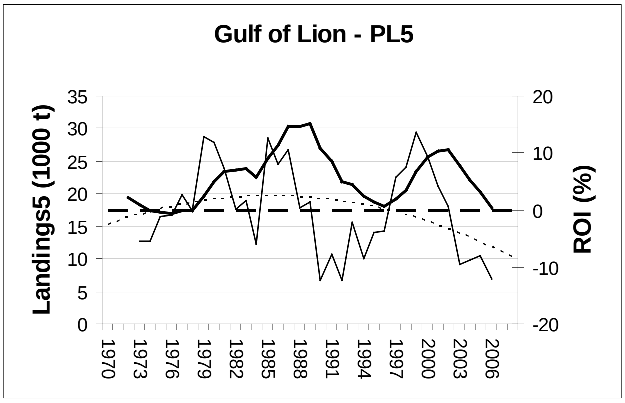












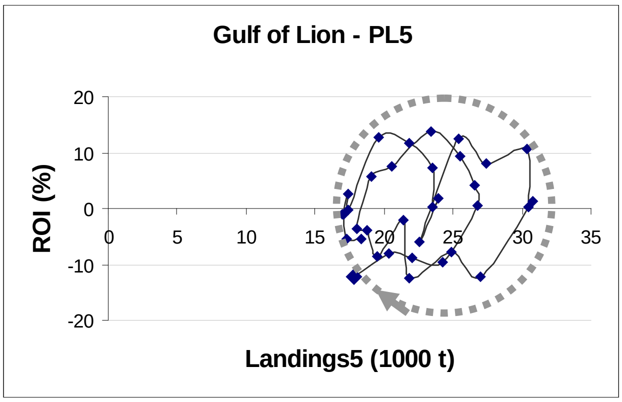


Plate 3B: Pelagic Fish. Development patterns in GFCM sub-areas 1970-2008

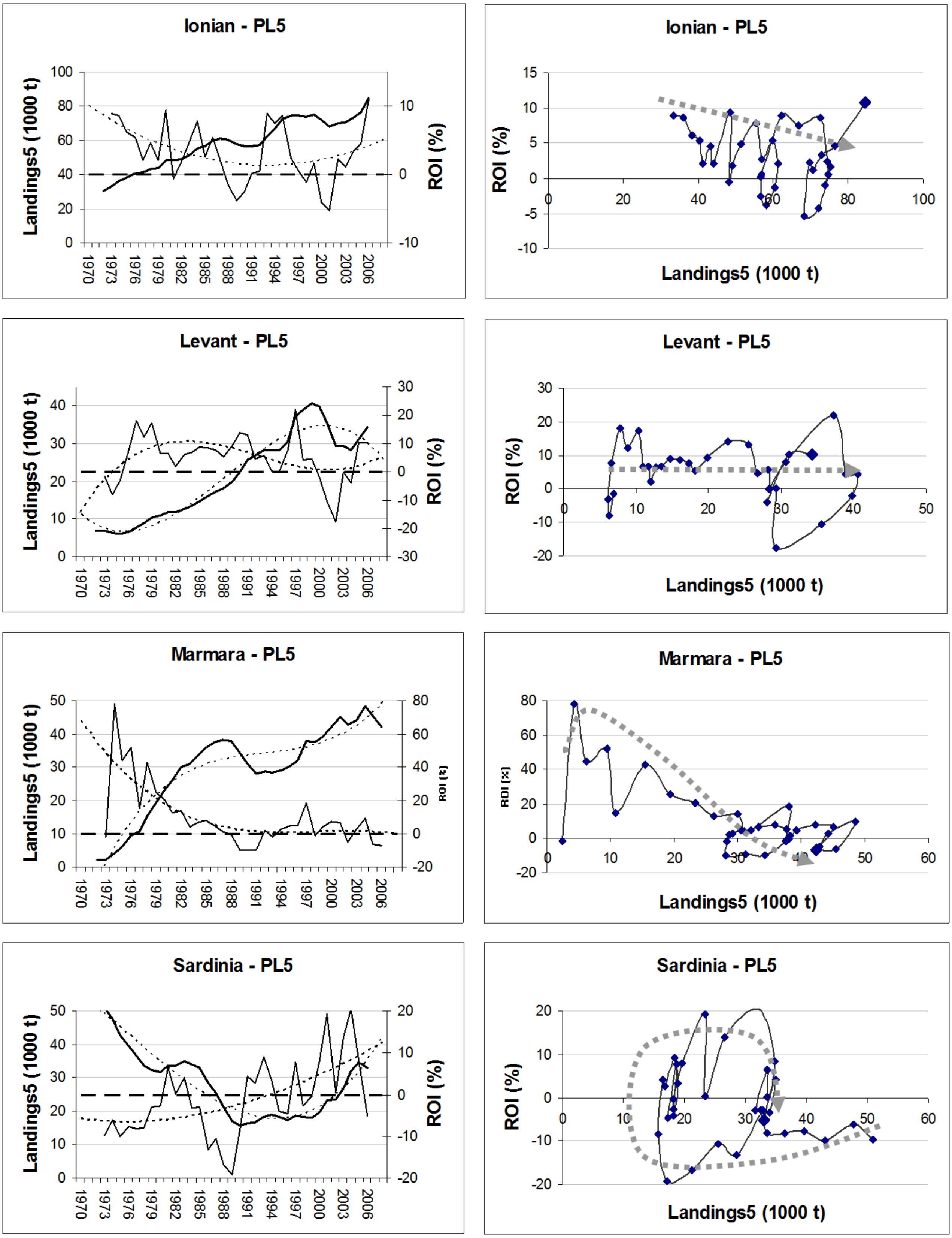
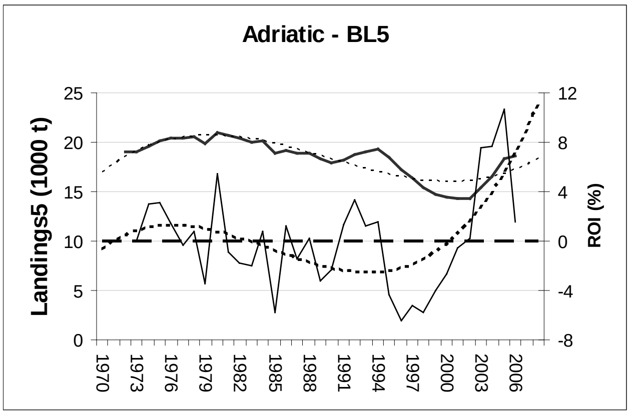
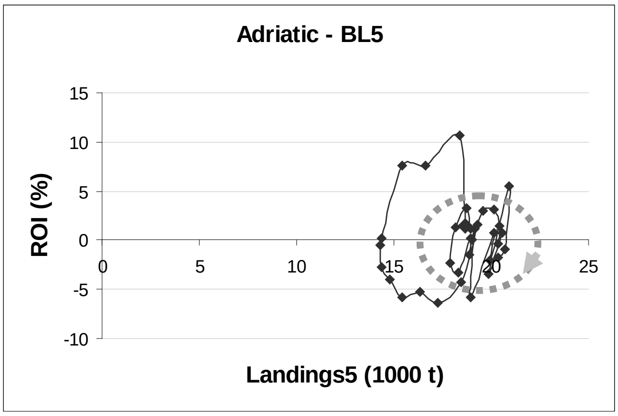
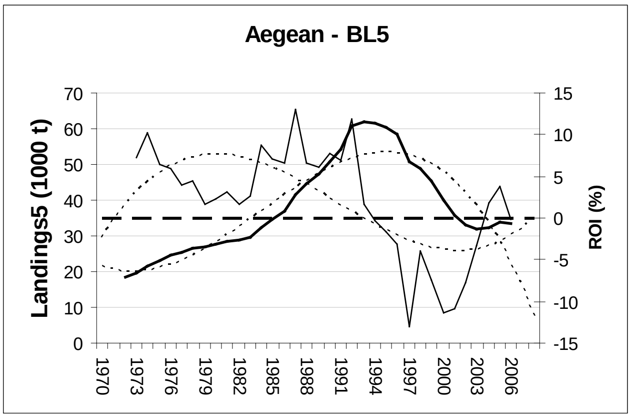
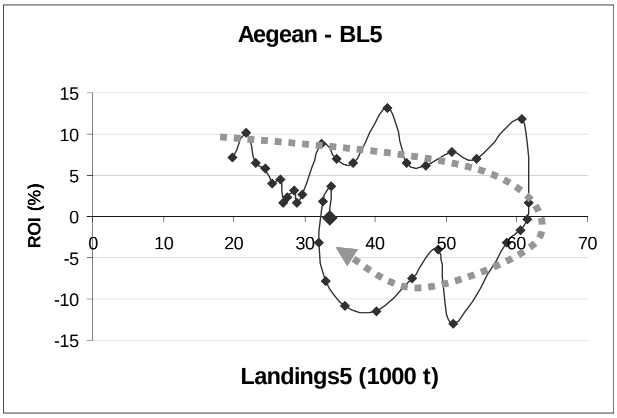


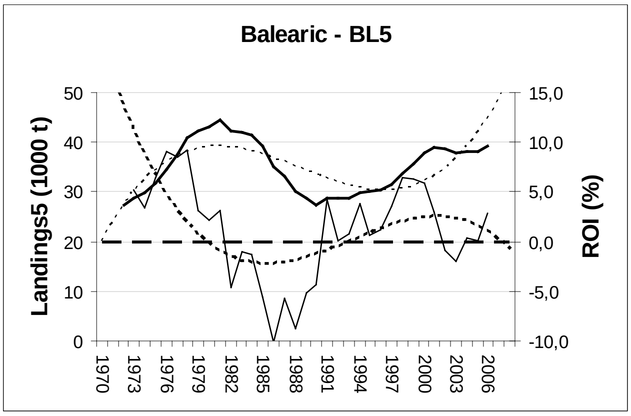
Plate 4A: Bottom Fish. Development patterns in GFCM sub-areas 1970-2008

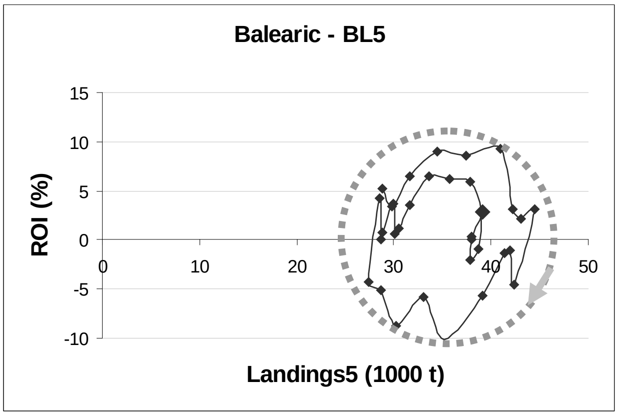


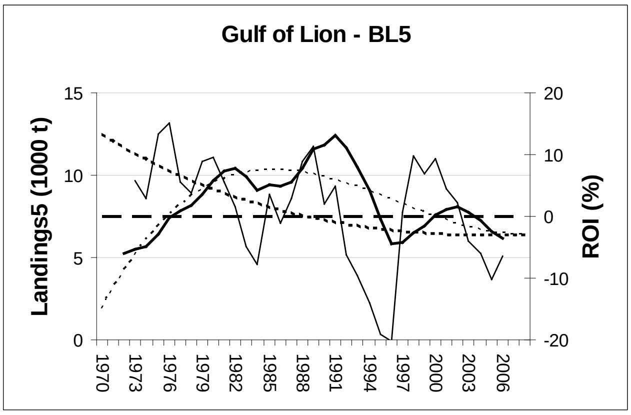












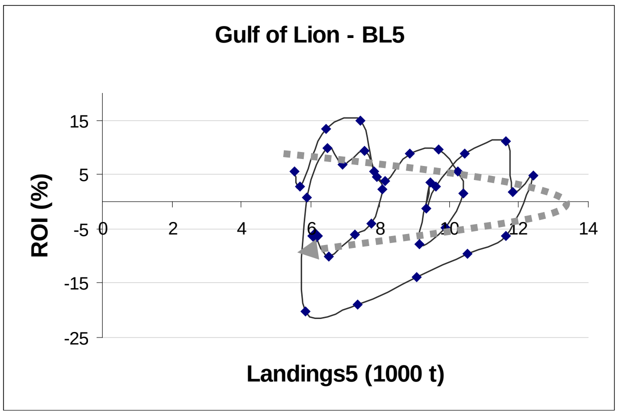


Plate 4B: Bottom Fish. Development patterns in GFCM sub-areas 1970-2008

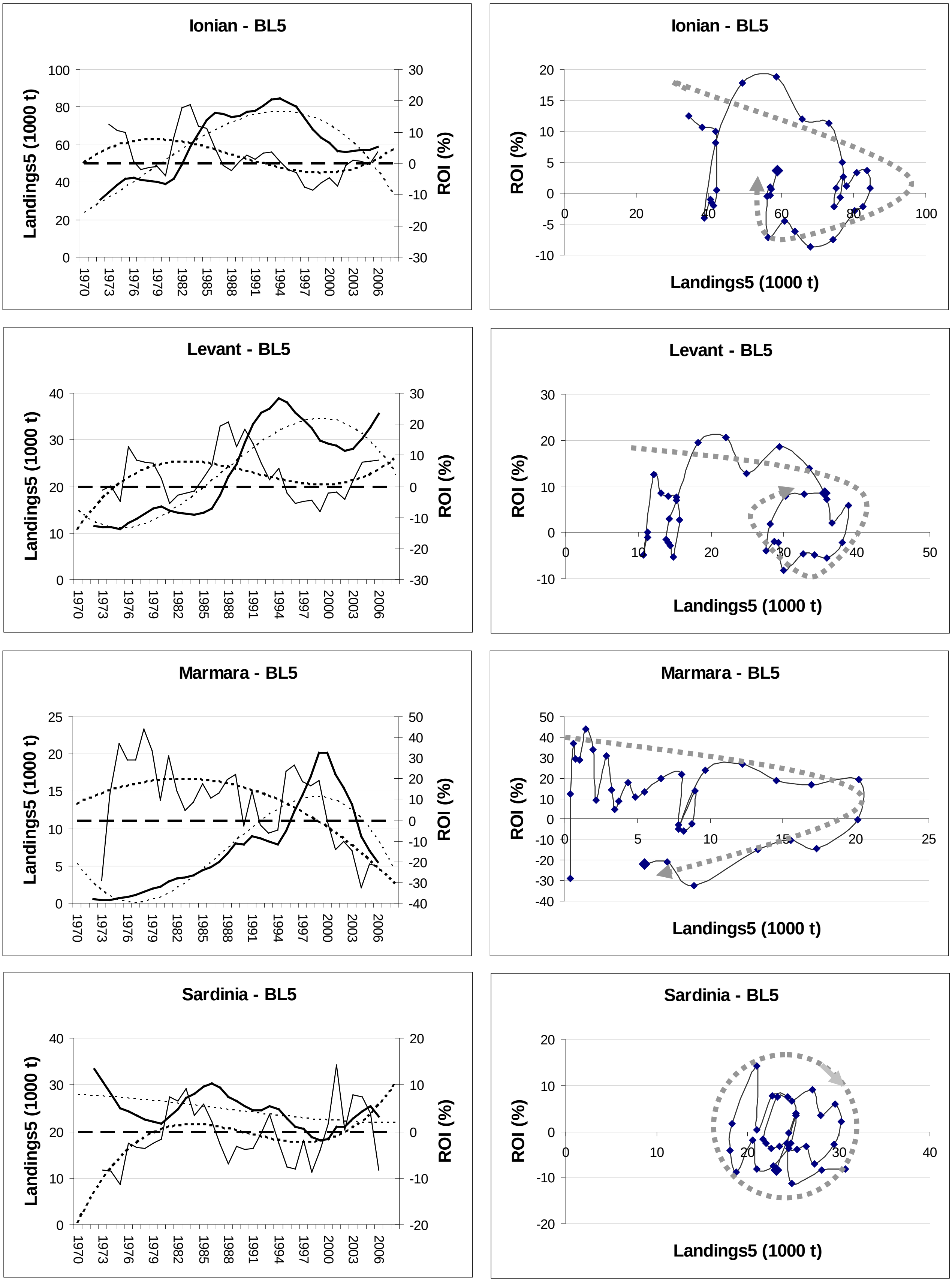


Plate 5A: Sharks and Rays. Development patterns in GFCM sub-areas

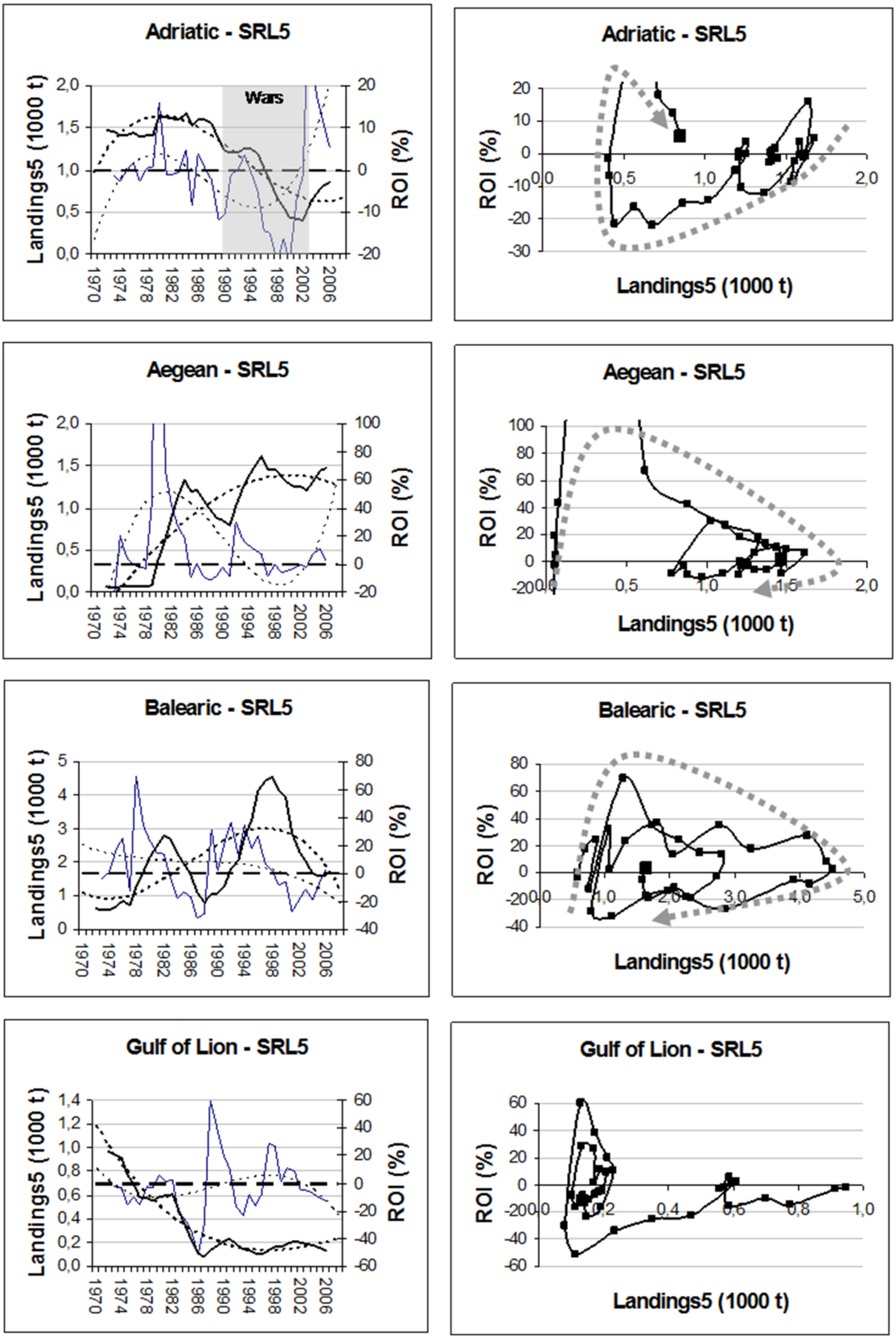
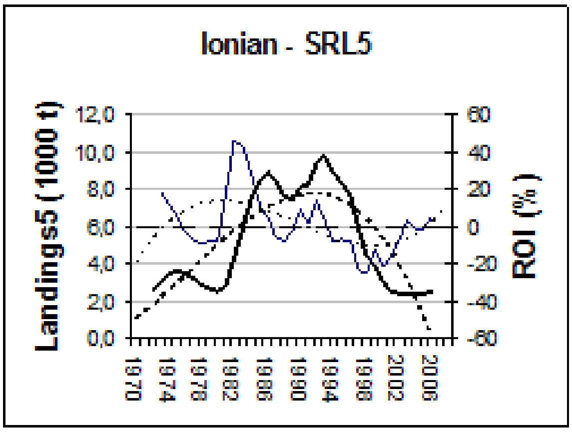
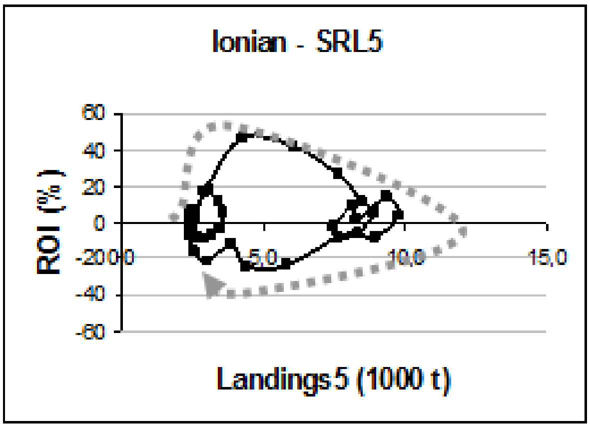
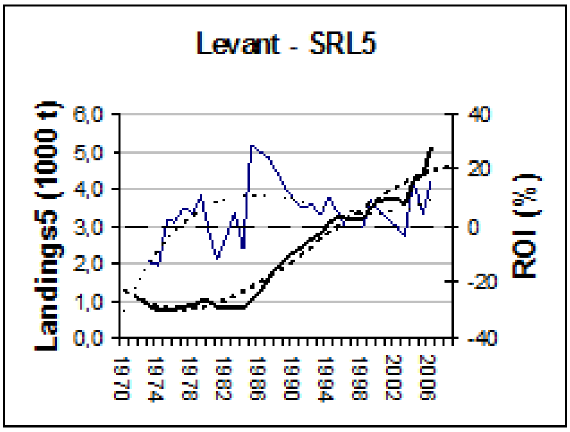
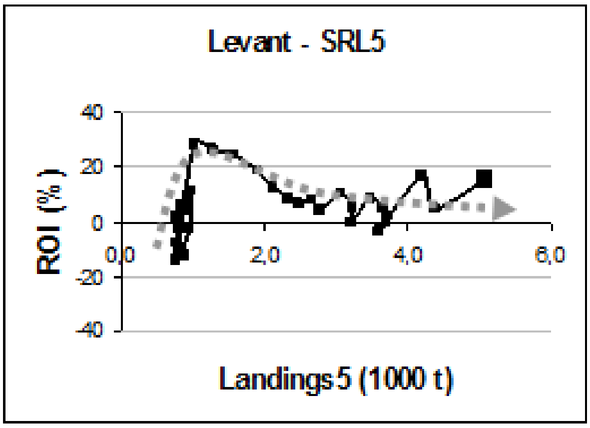


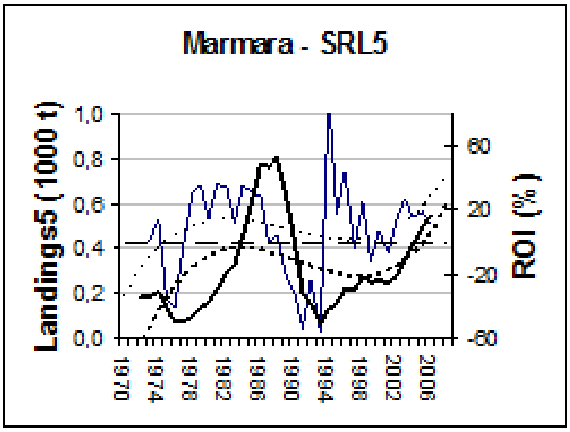
Plate 5B: Sharks and Rays. Development patterns in GFCM sub-areas

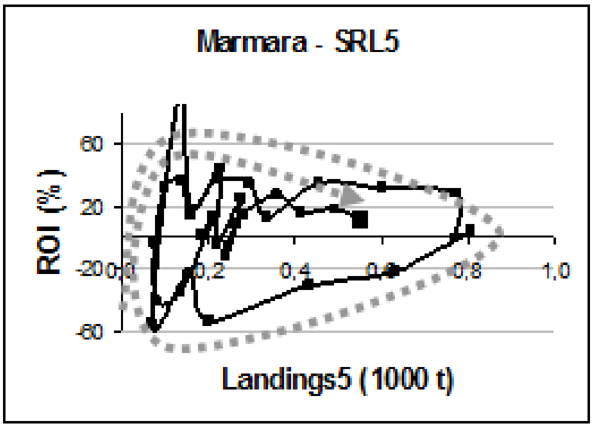


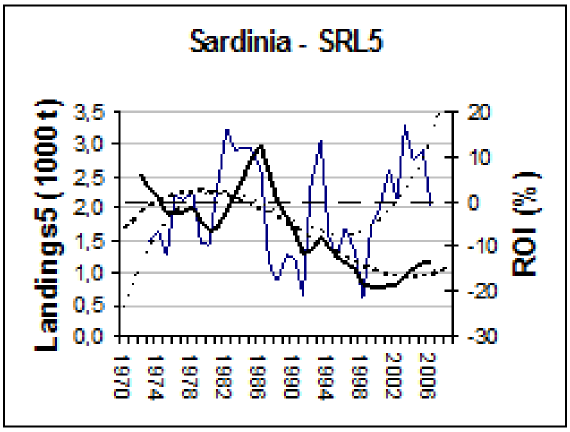












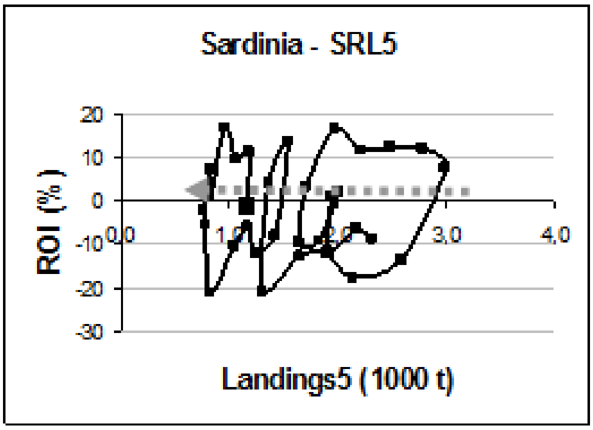
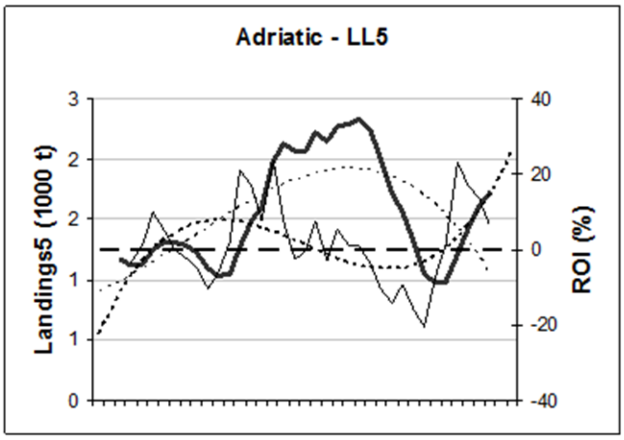
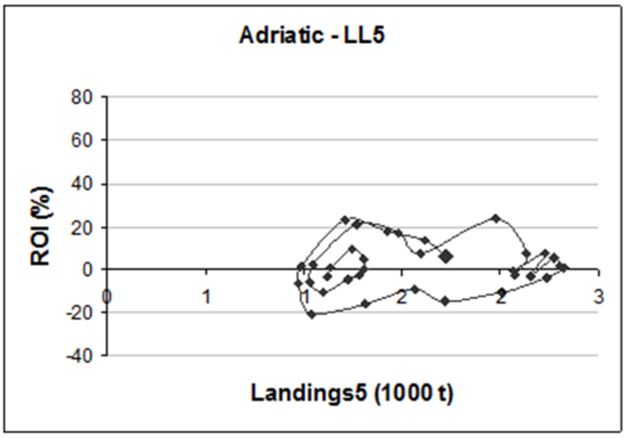
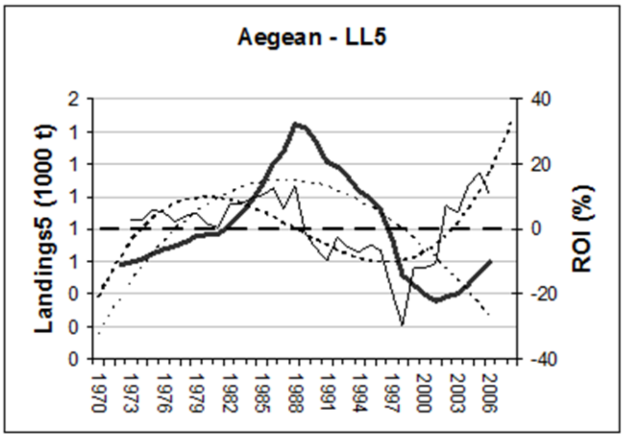
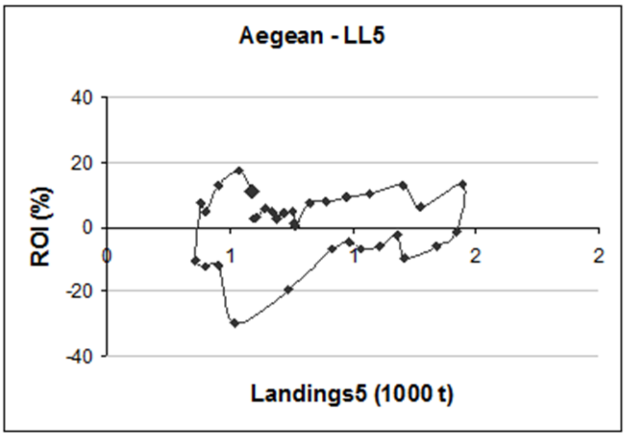


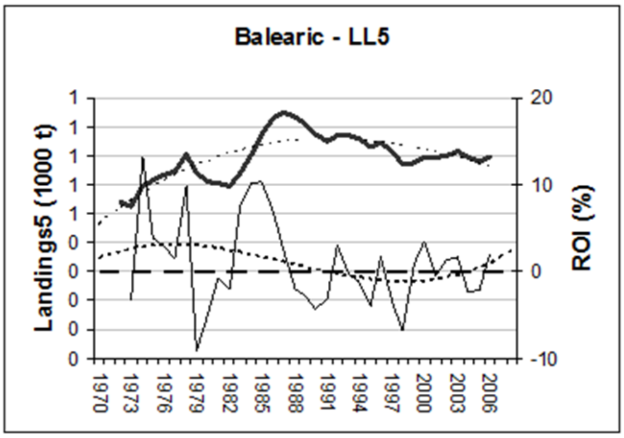
Plate 6A: Lobsters: Development patterns in GFCM sub-areas

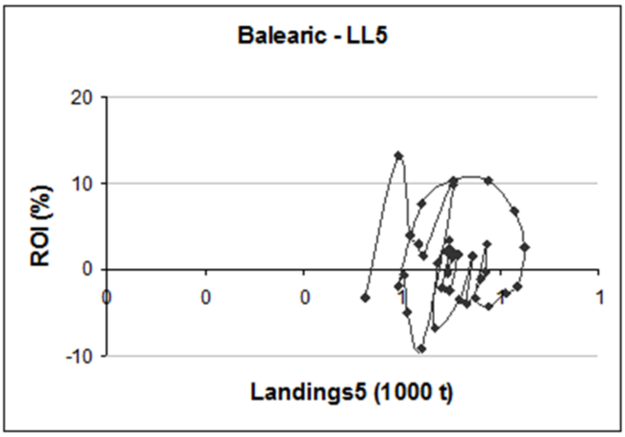


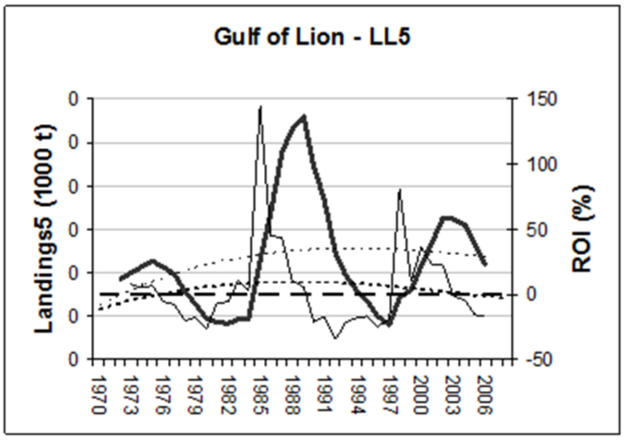












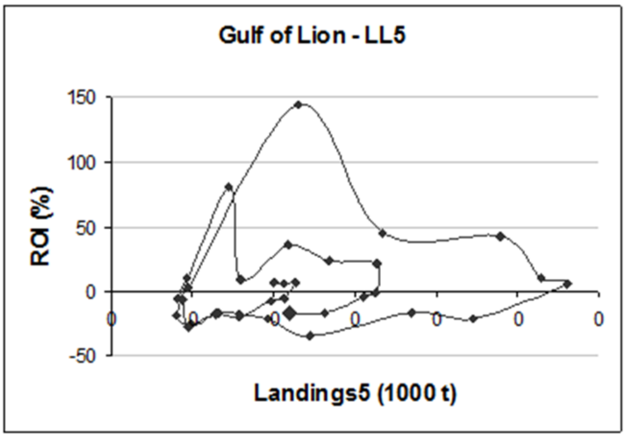


Plate 6B: Lobsters: Development patterns in GFCM sub-areas

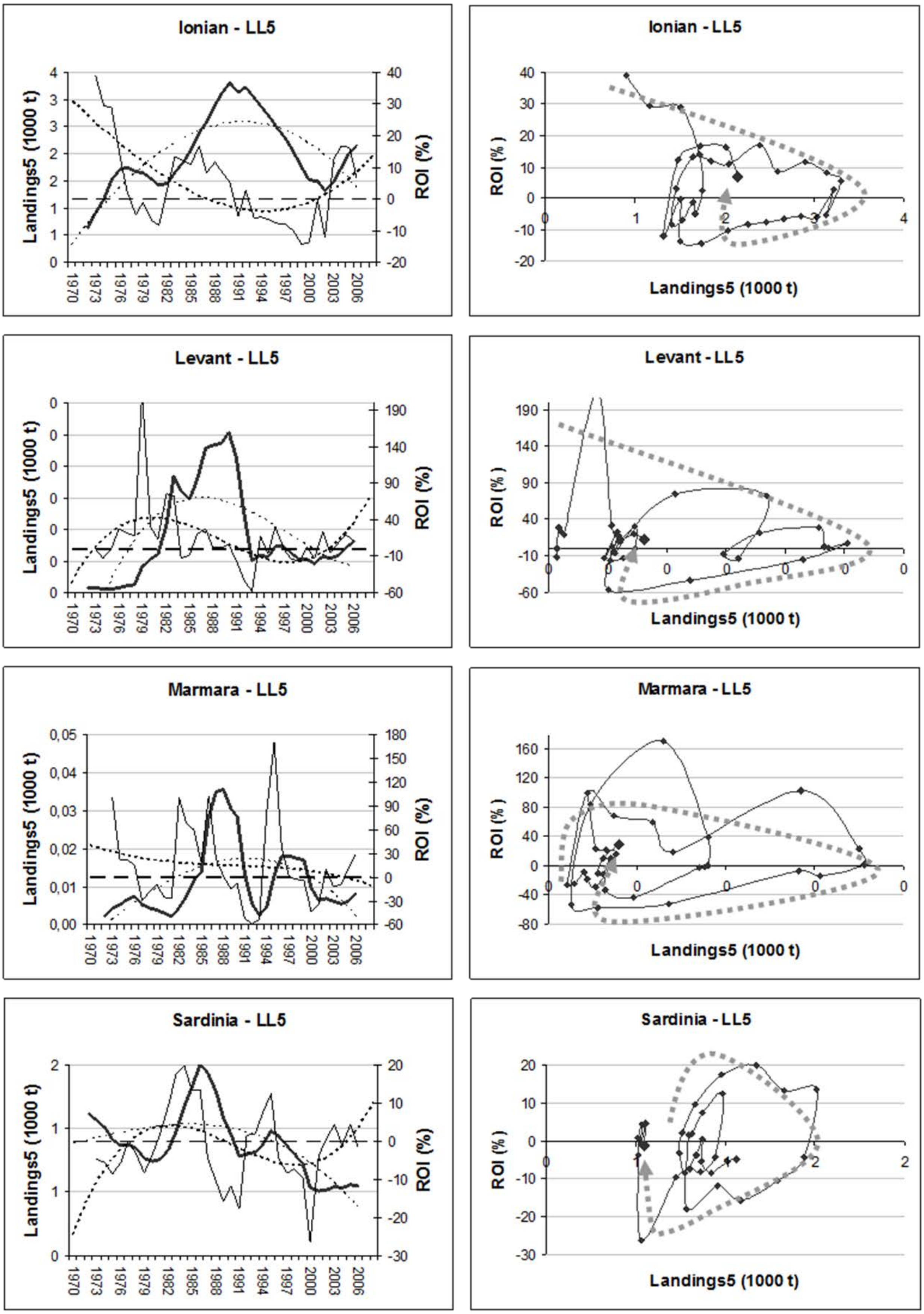
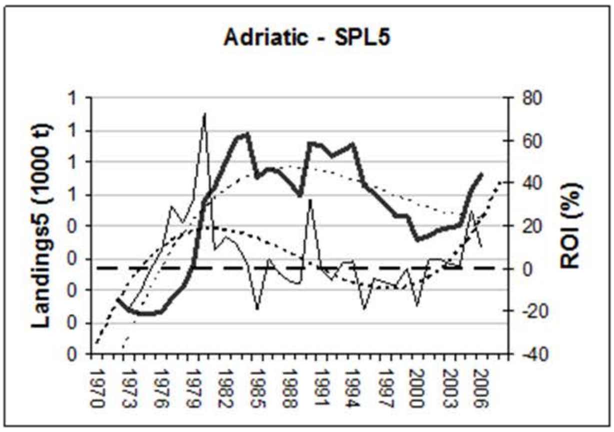
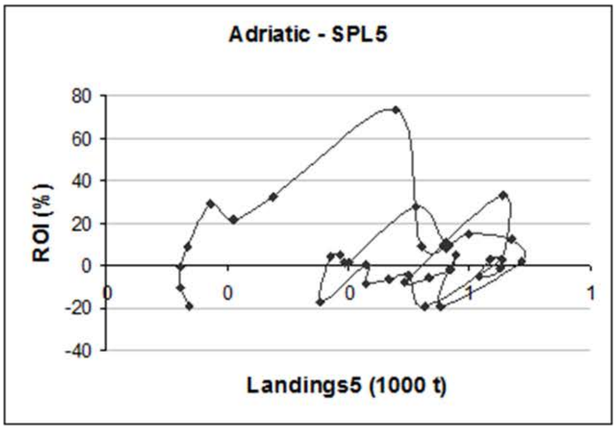
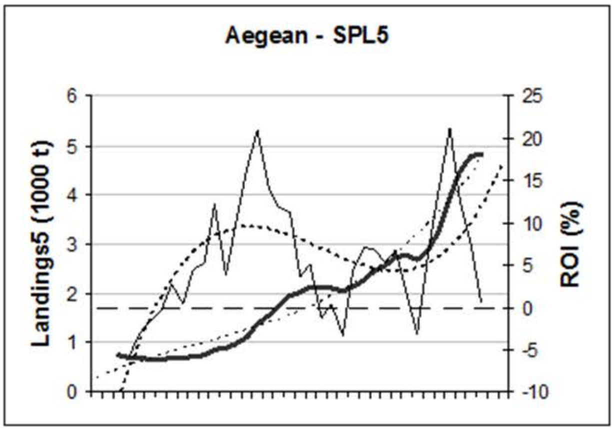
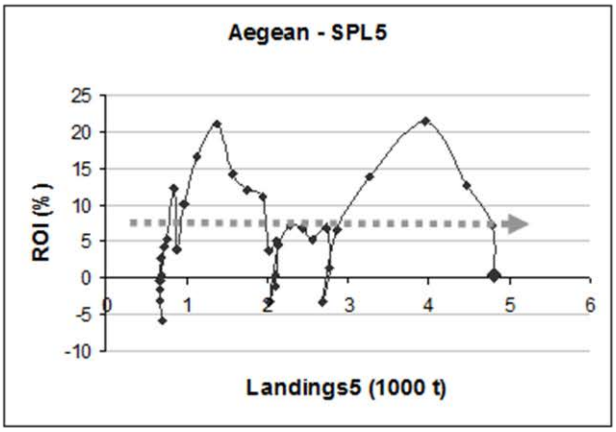


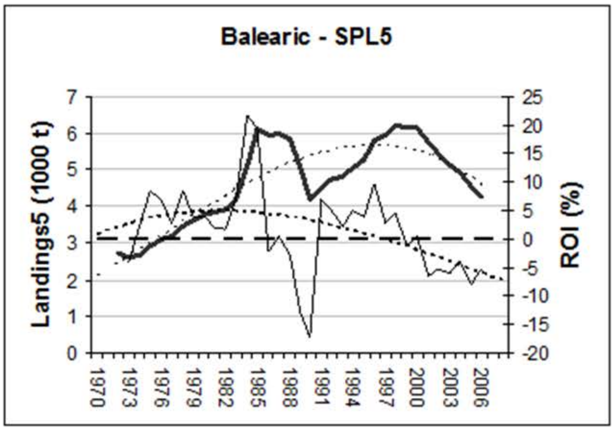
Plate 7A: Shrimps and Prawns: Development patterns in GFCM sub-areas 1970-2008

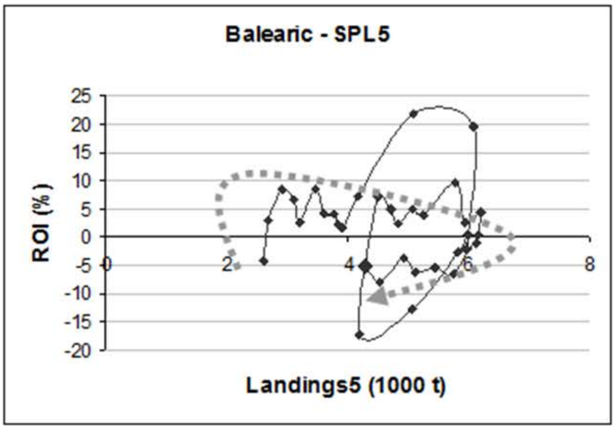


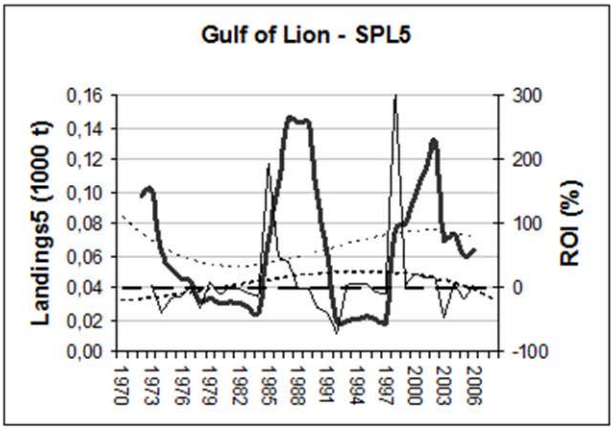












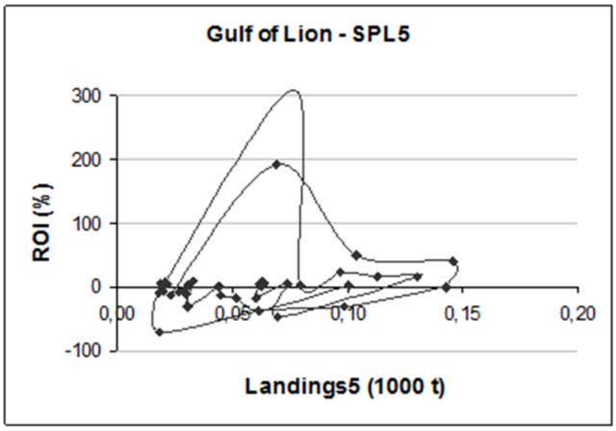
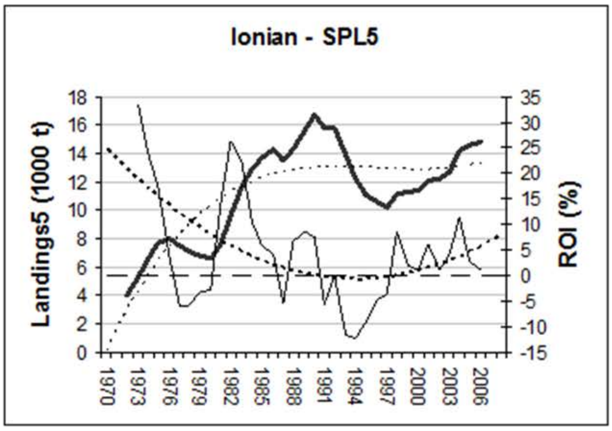
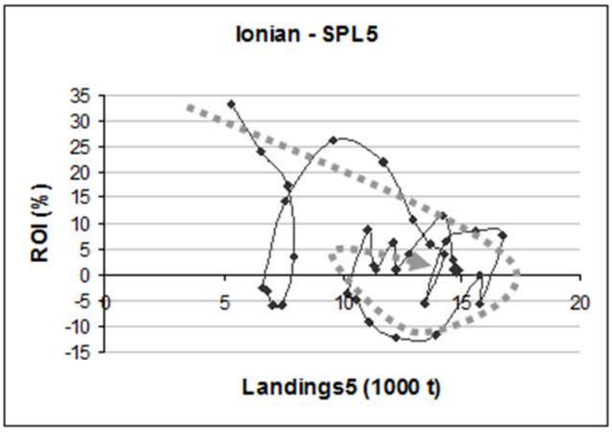
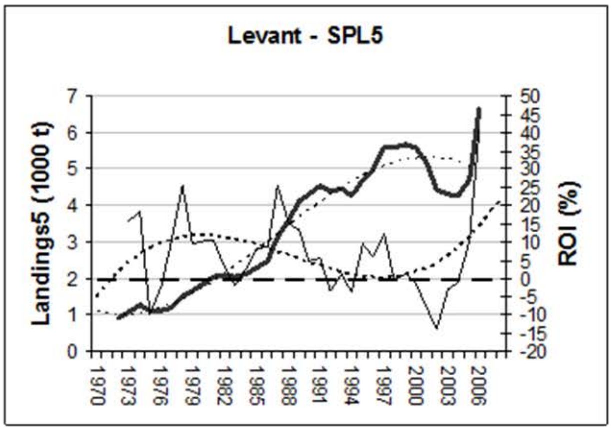
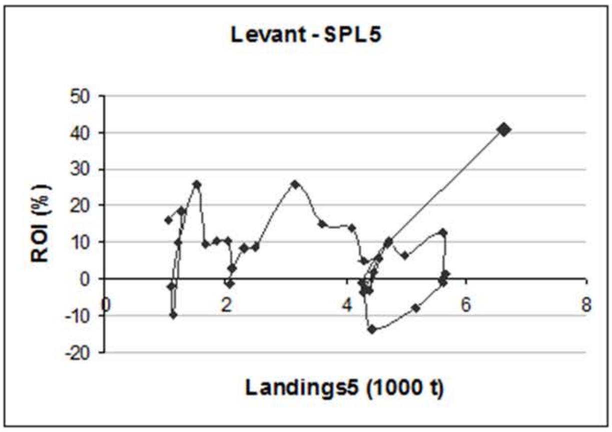


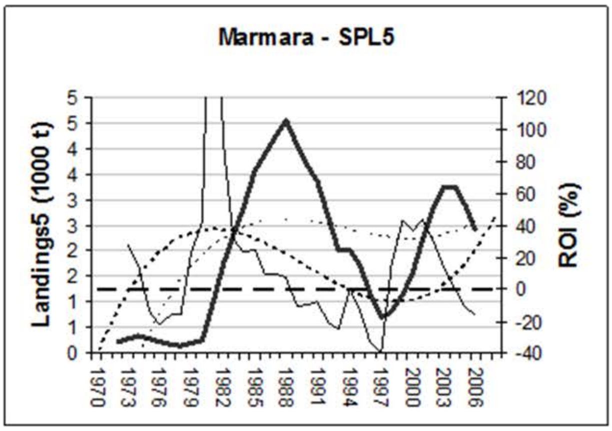
Plate 7B: Shrimps and Prawns: Development patterns in GFCM sub-areas 1970-2008

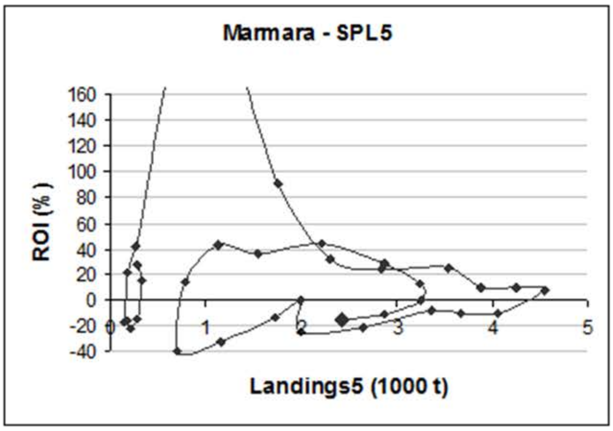


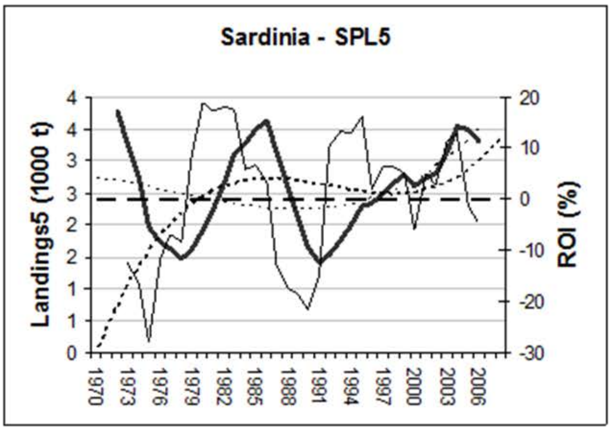












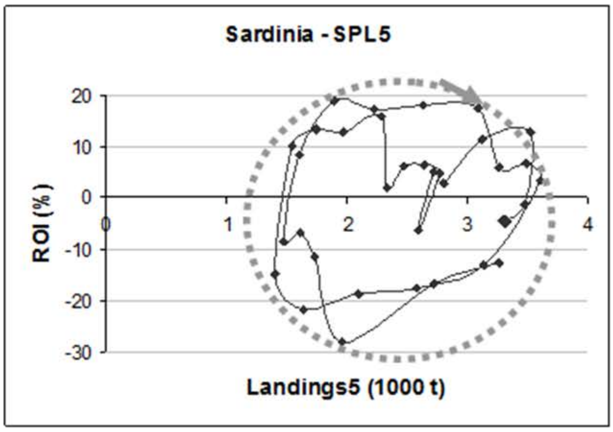


Plate 8A: Squids, Cuttlefish & Octopus: Development patterns in GFCM sub-areas 1970-2008

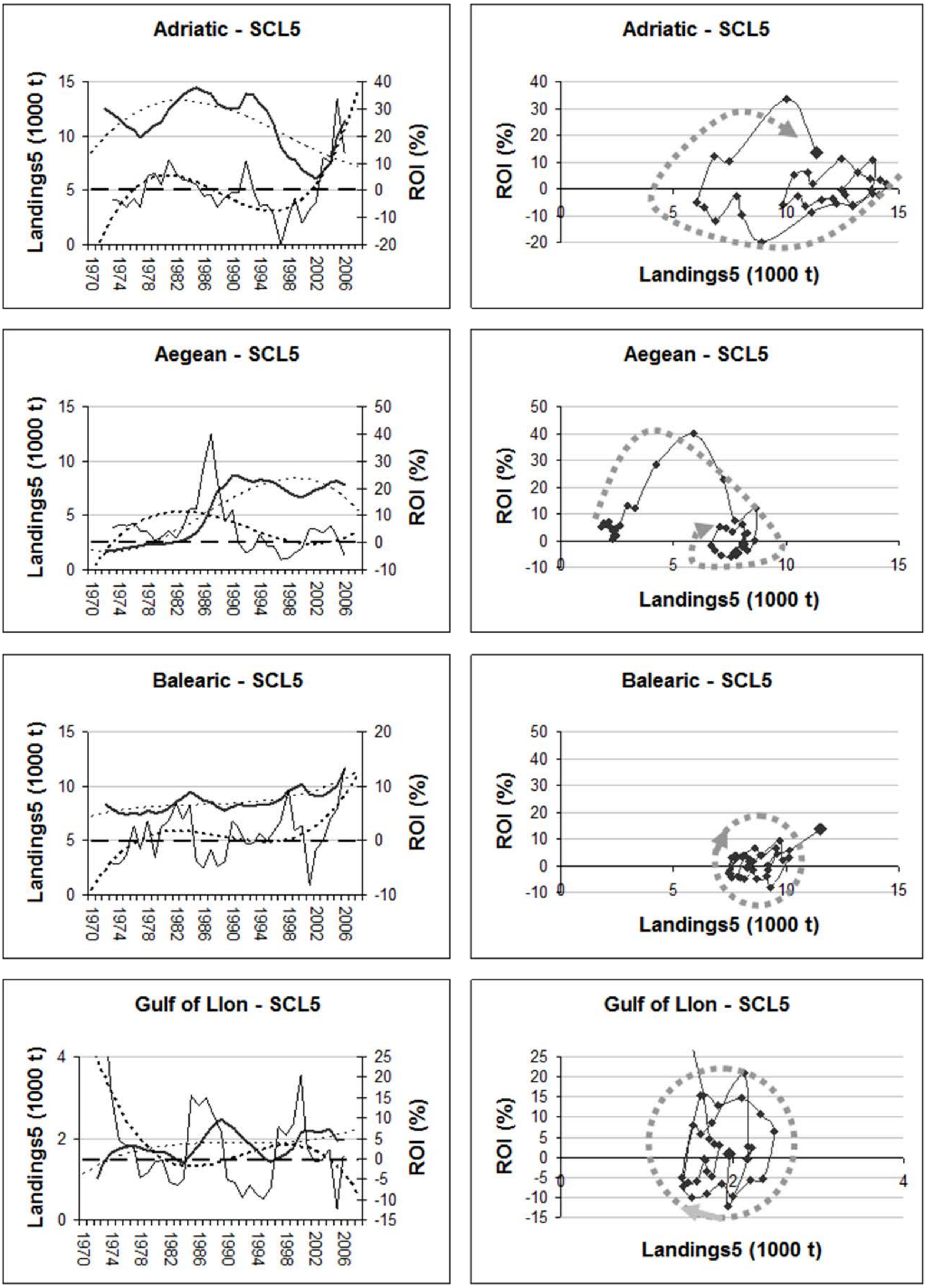


Plate 8B: Squids, Cuttlefish & Octopus: Development patterns in GFCM sub-areas 1970-2008

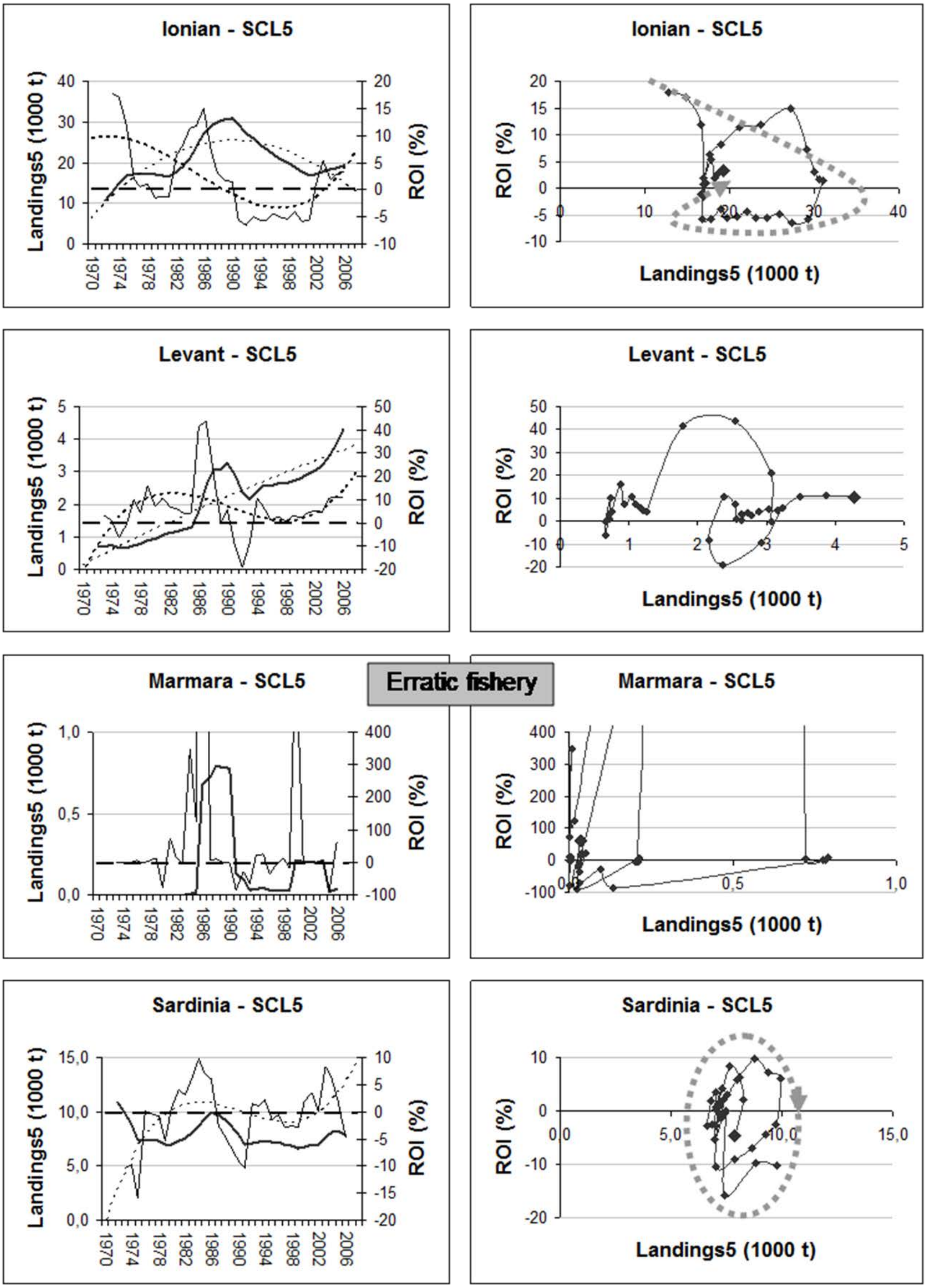
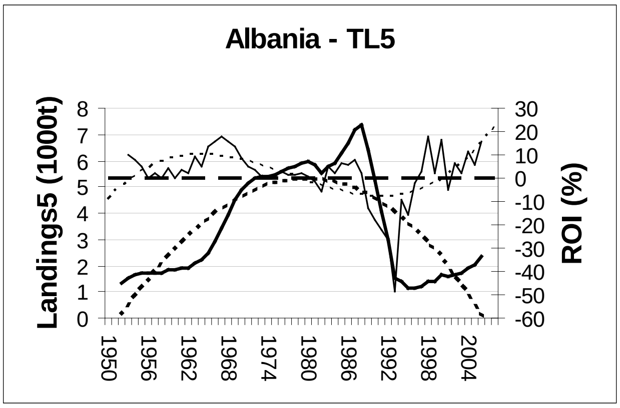
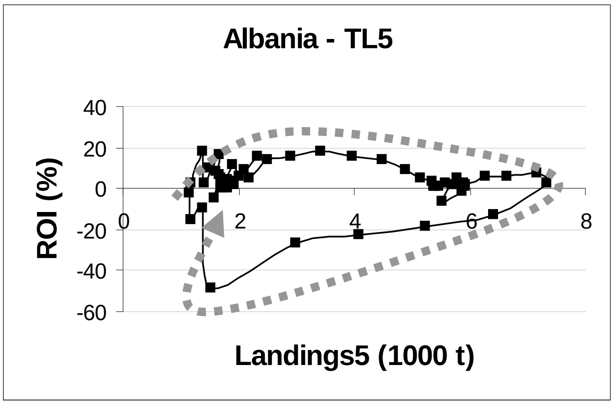
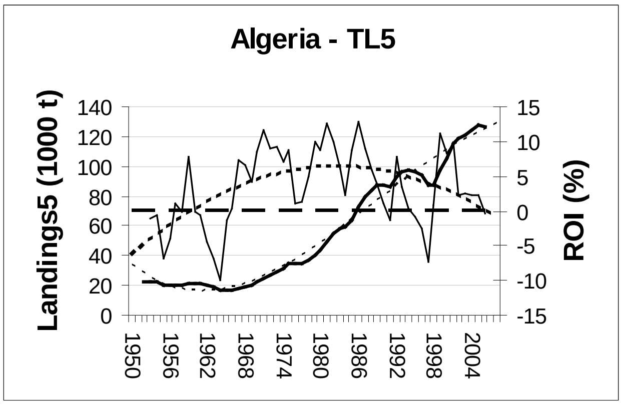
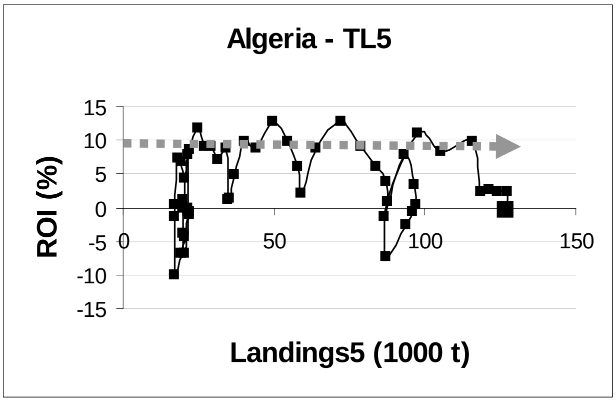


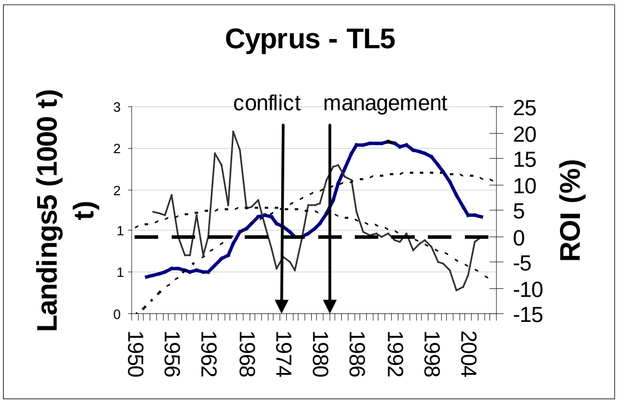
Plate 9A: Total Fish. National development patterns 1950-2008

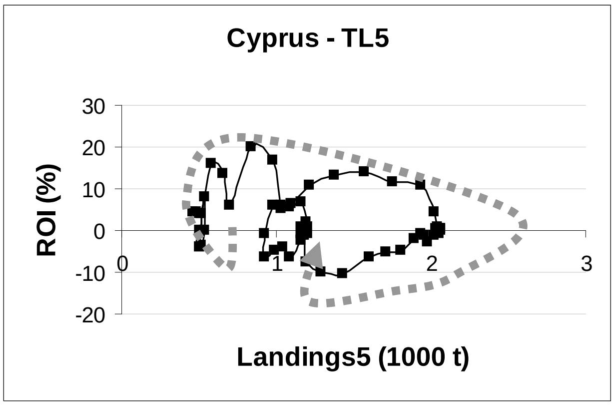


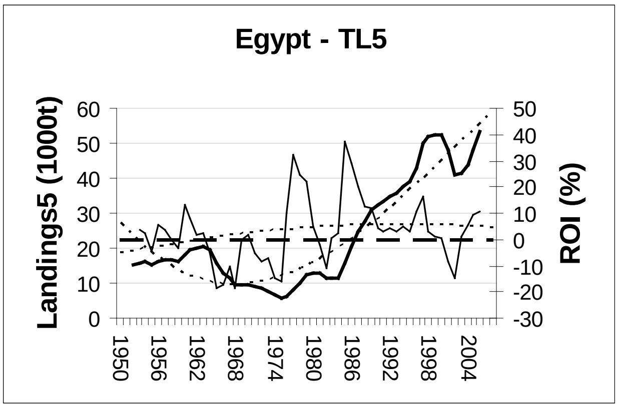












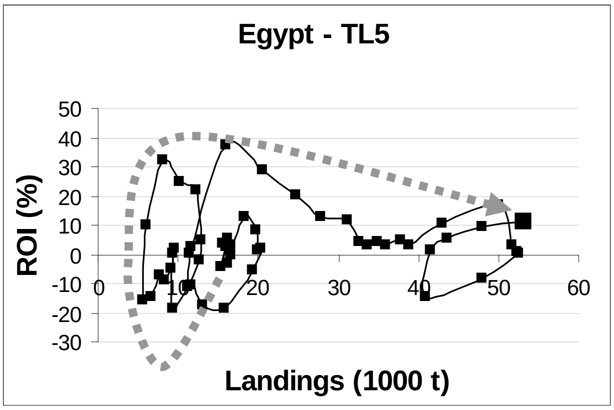


Plate 9B: Total Fish. National development patterns 1950-2008

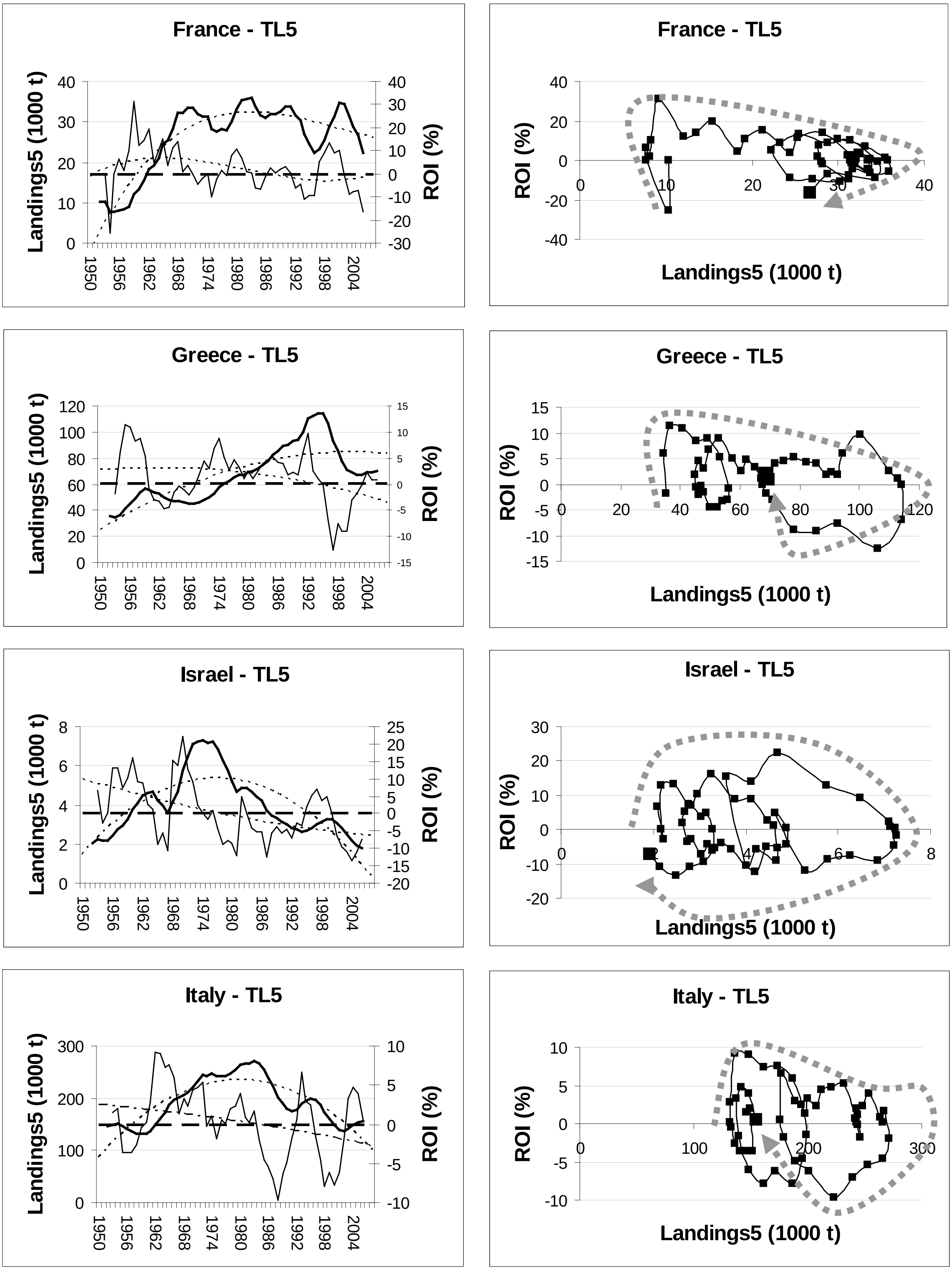
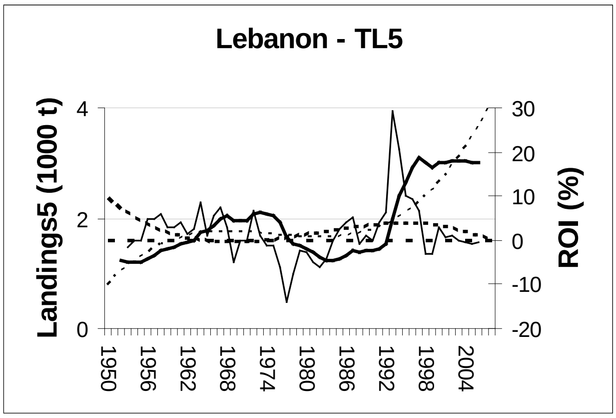
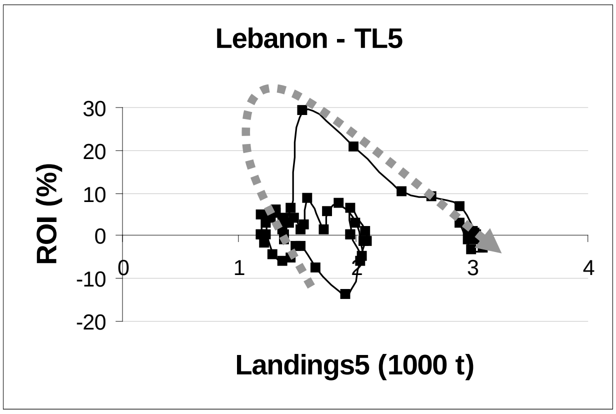
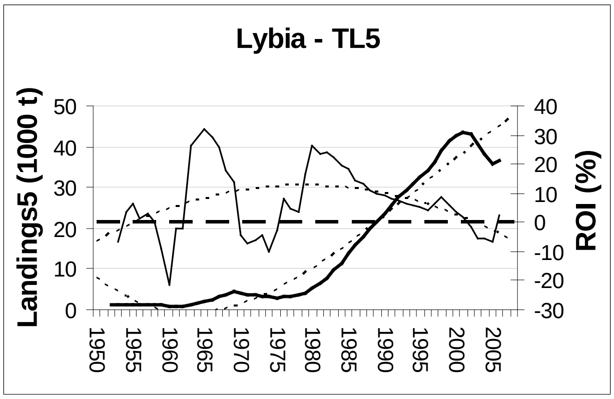
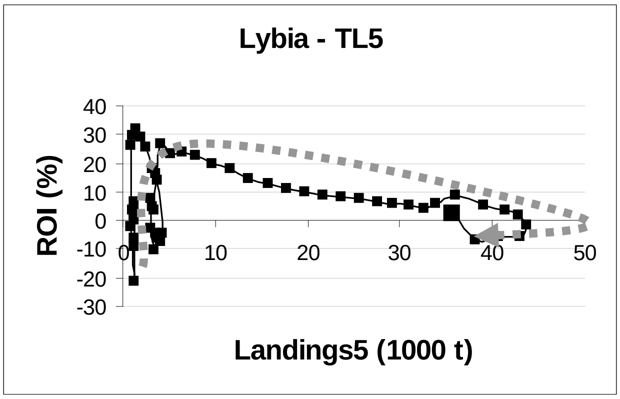


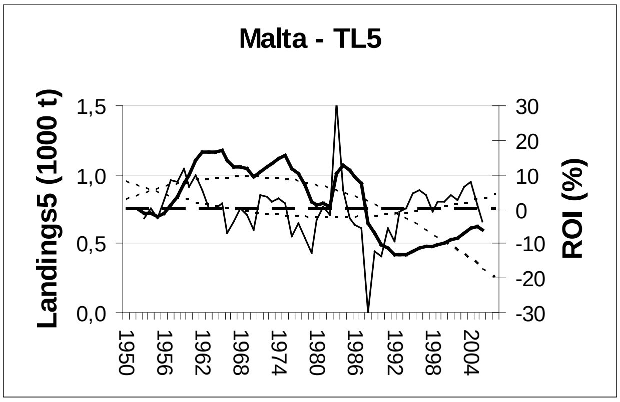
Plate 9C: Total Fish. National development patterns 1950-2008

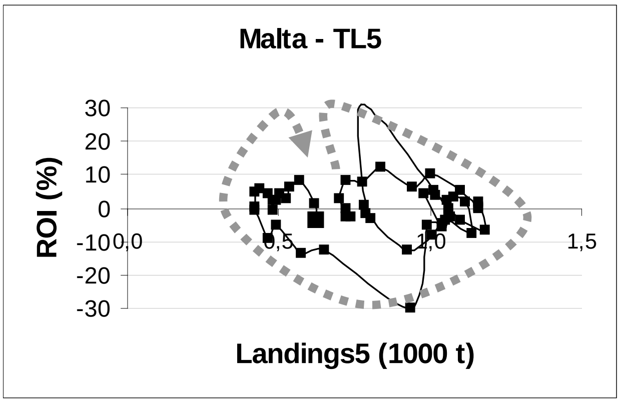


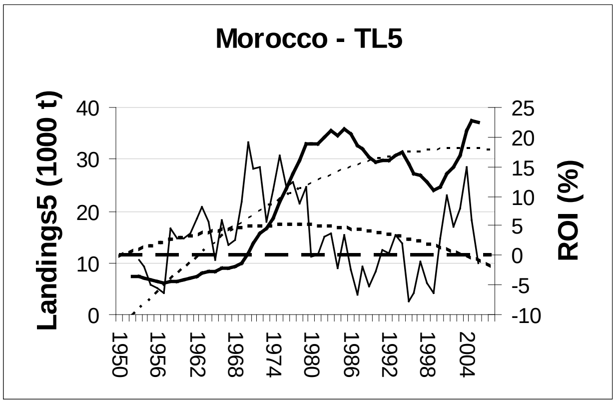












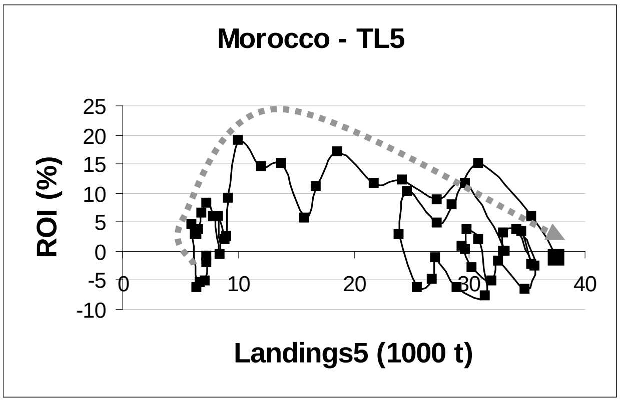
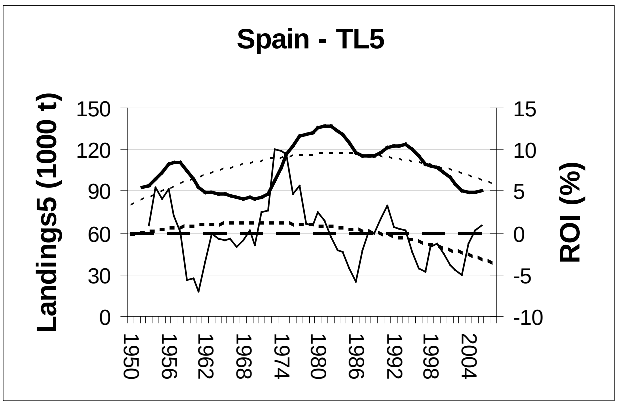
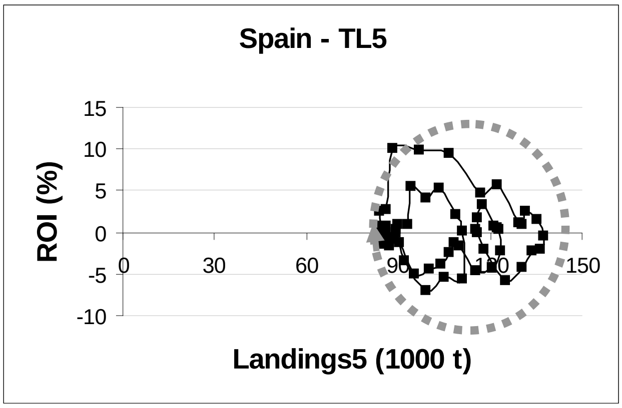
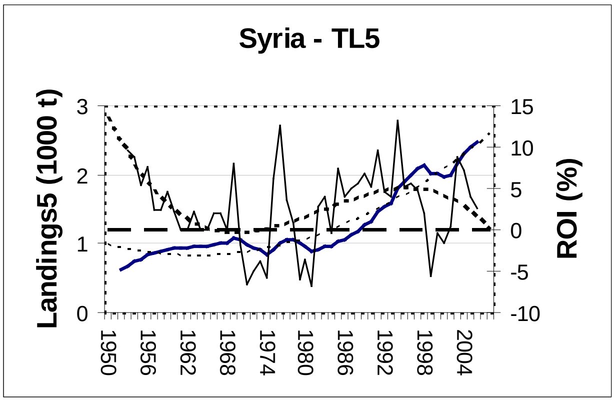
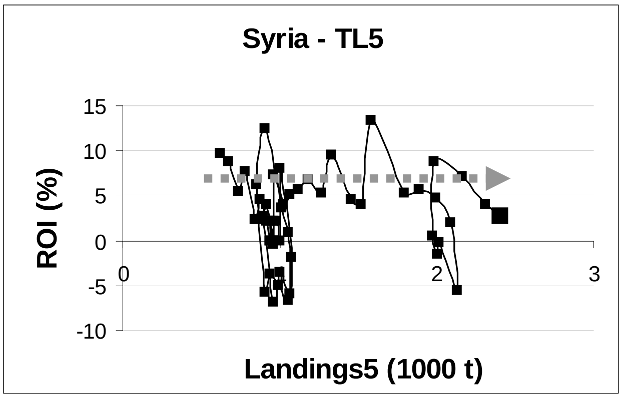


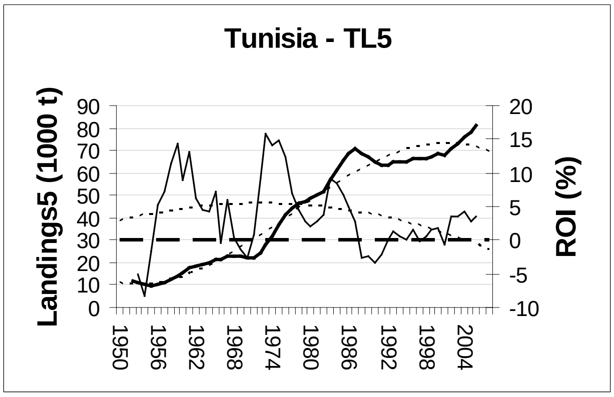
Plate 9D: Total Fish. National development patterns 1950-2008

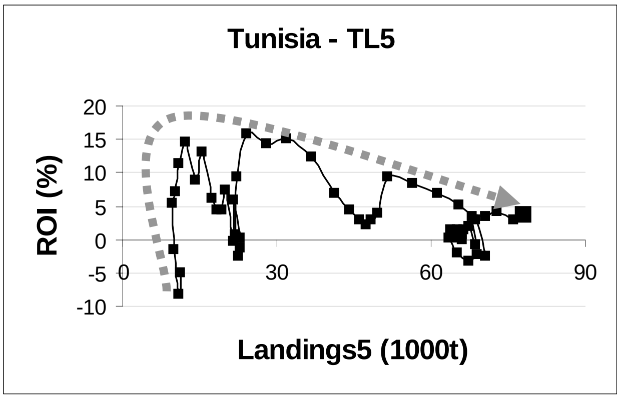


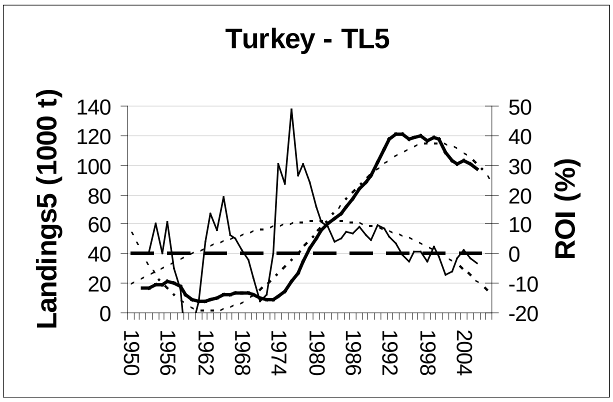












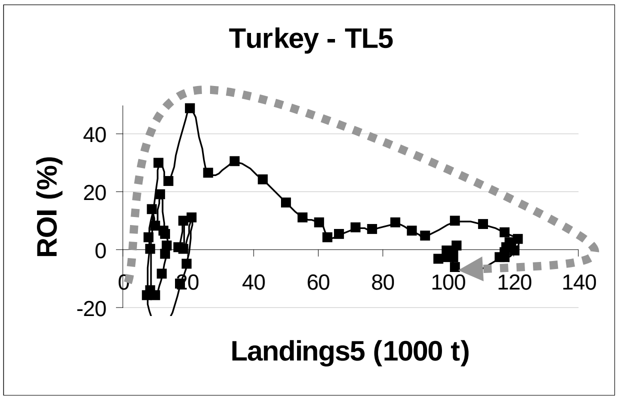
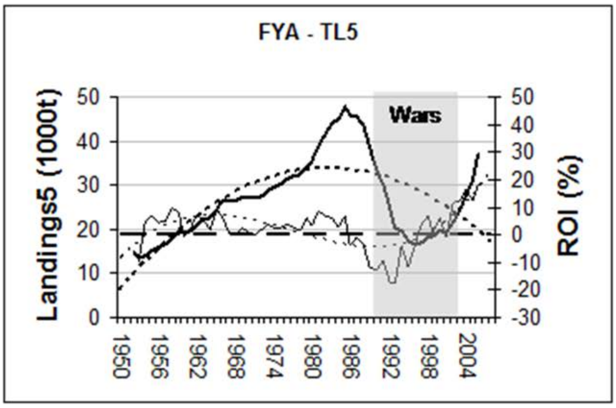
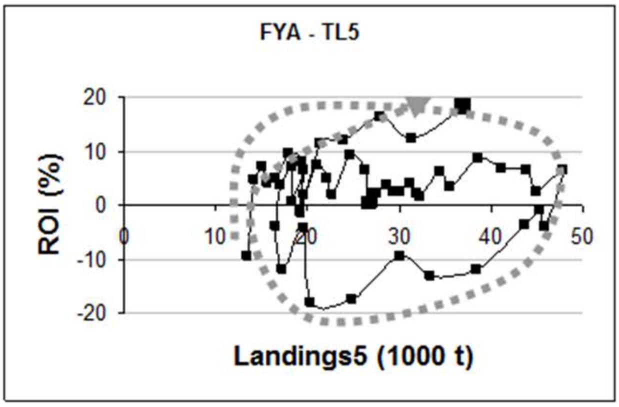
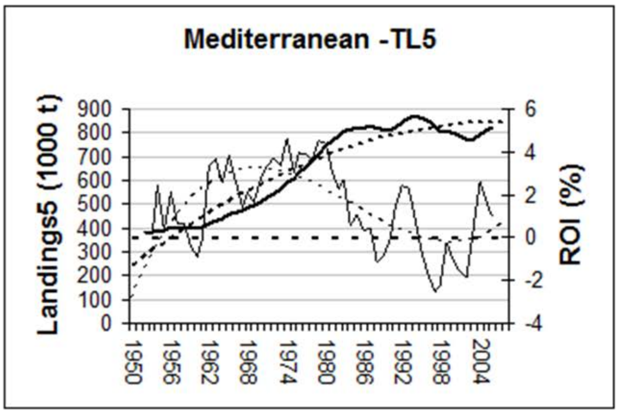


Plate 9E: Total Fish. National development patterns 1950-2008 and total for the Mediterranean







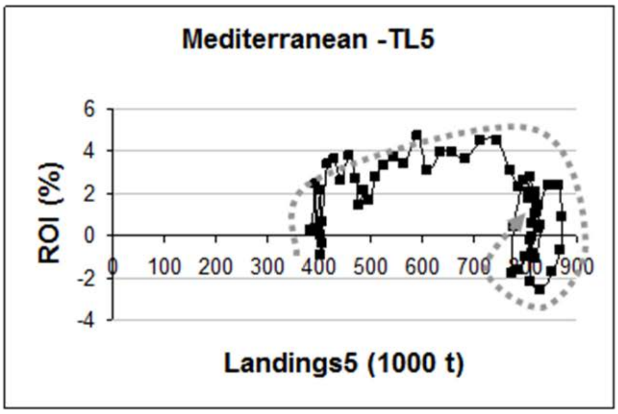
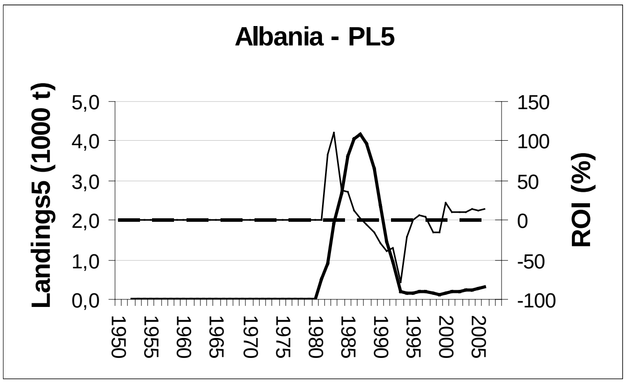
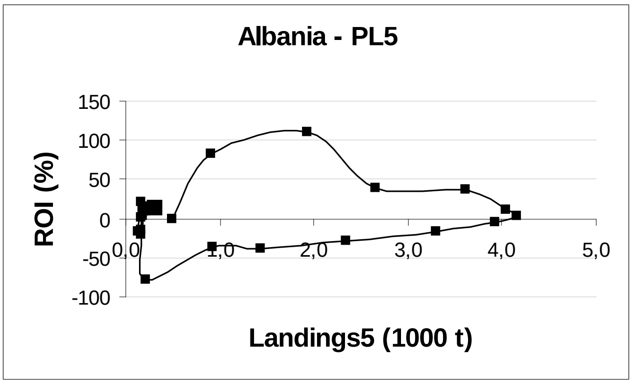
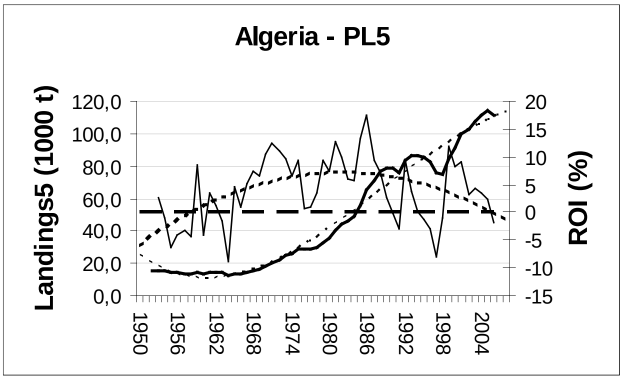
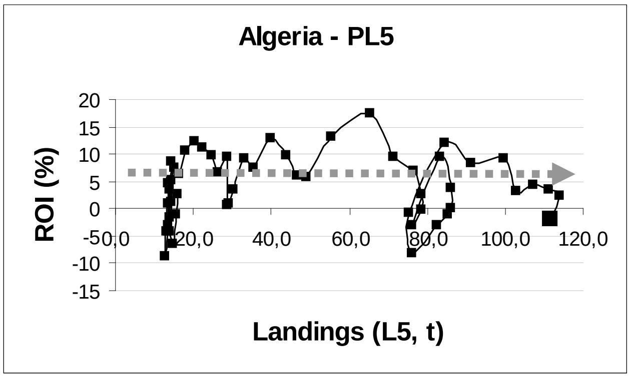


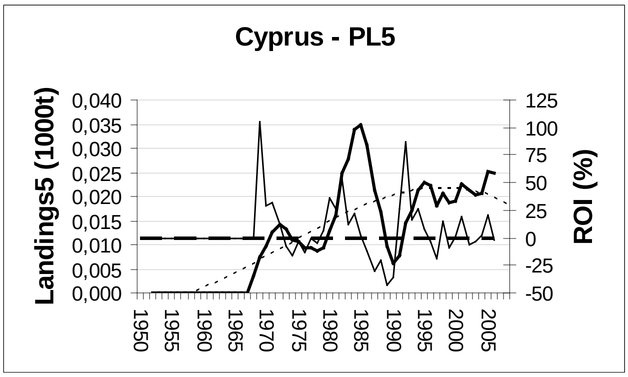
Plate 10A: Pelagic Fish. National Development patterns 1950-2008

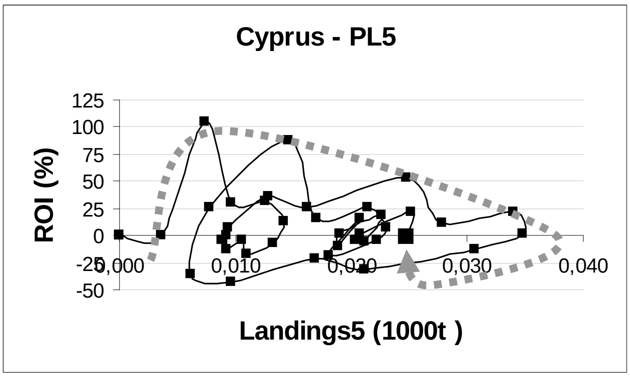


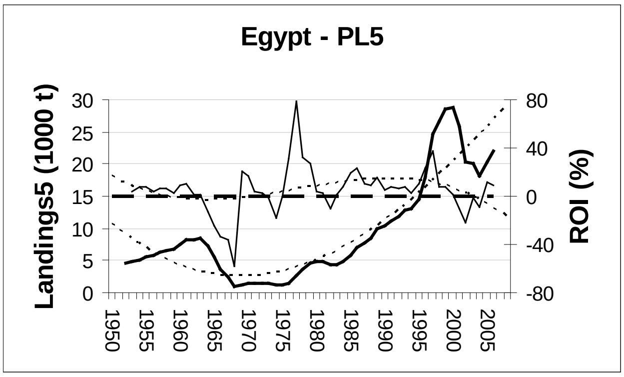












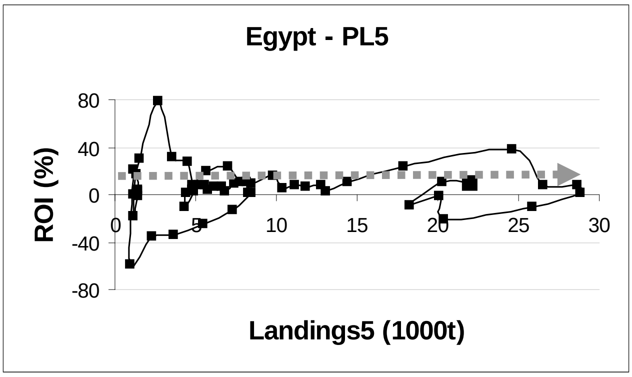
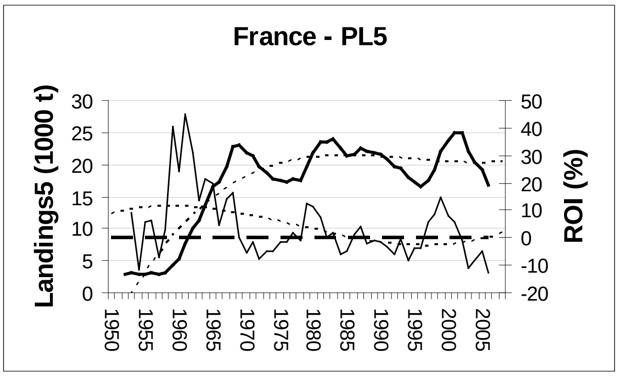
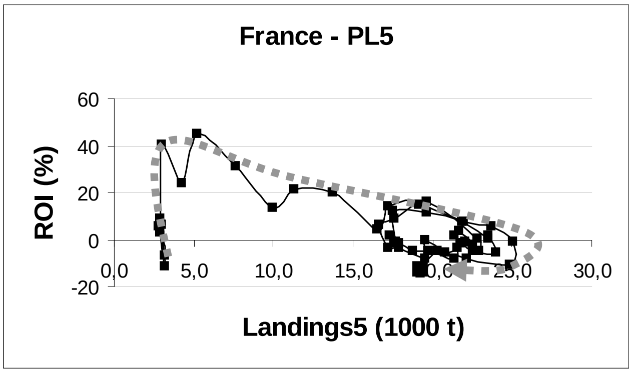
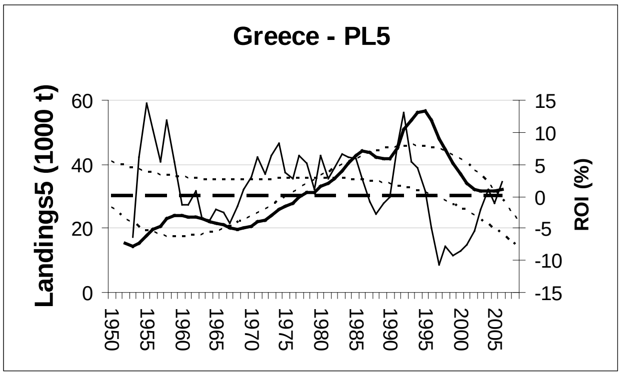
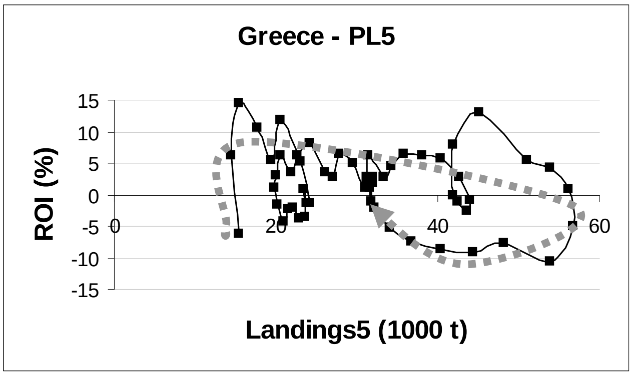


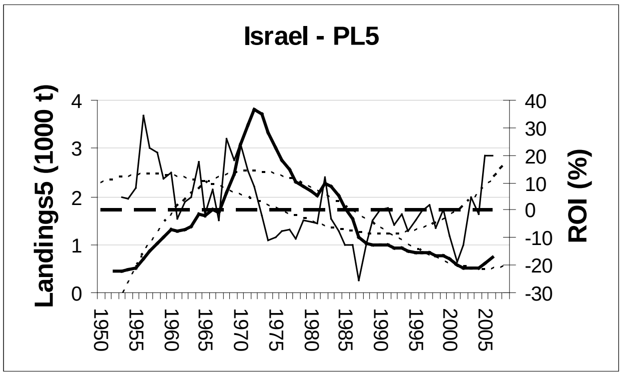
Plate 10B: Pelagic Fish. National Development patterns 1950-2008 (Continued)

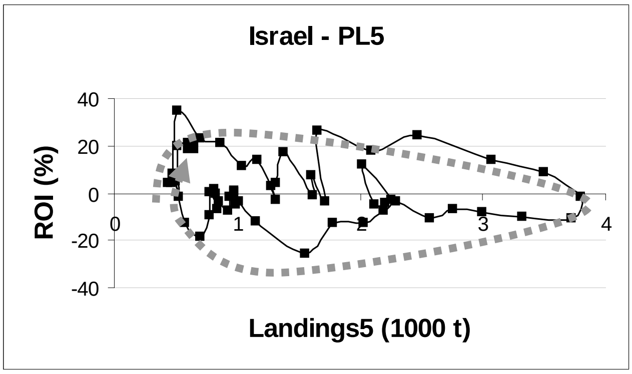


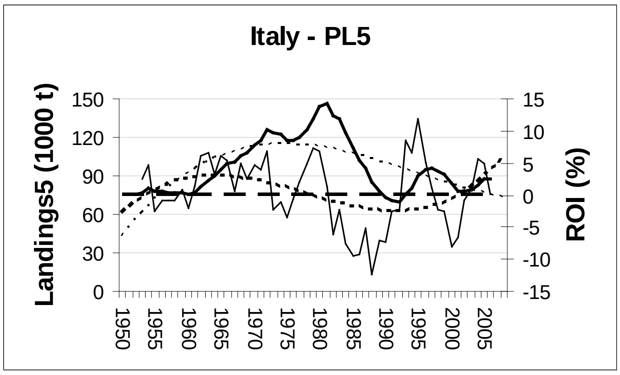












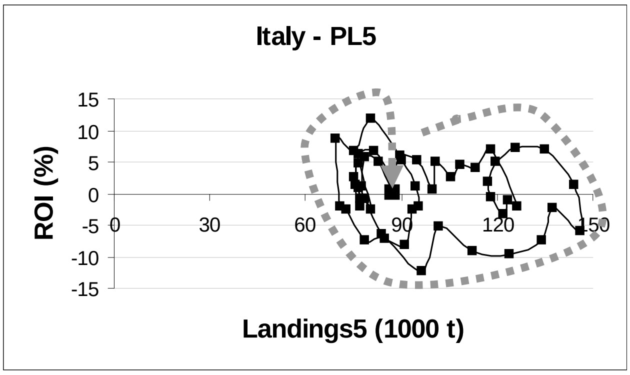


Plate 10C: Pelagic Fish. National Development patterns 1950-2008 (Continued)

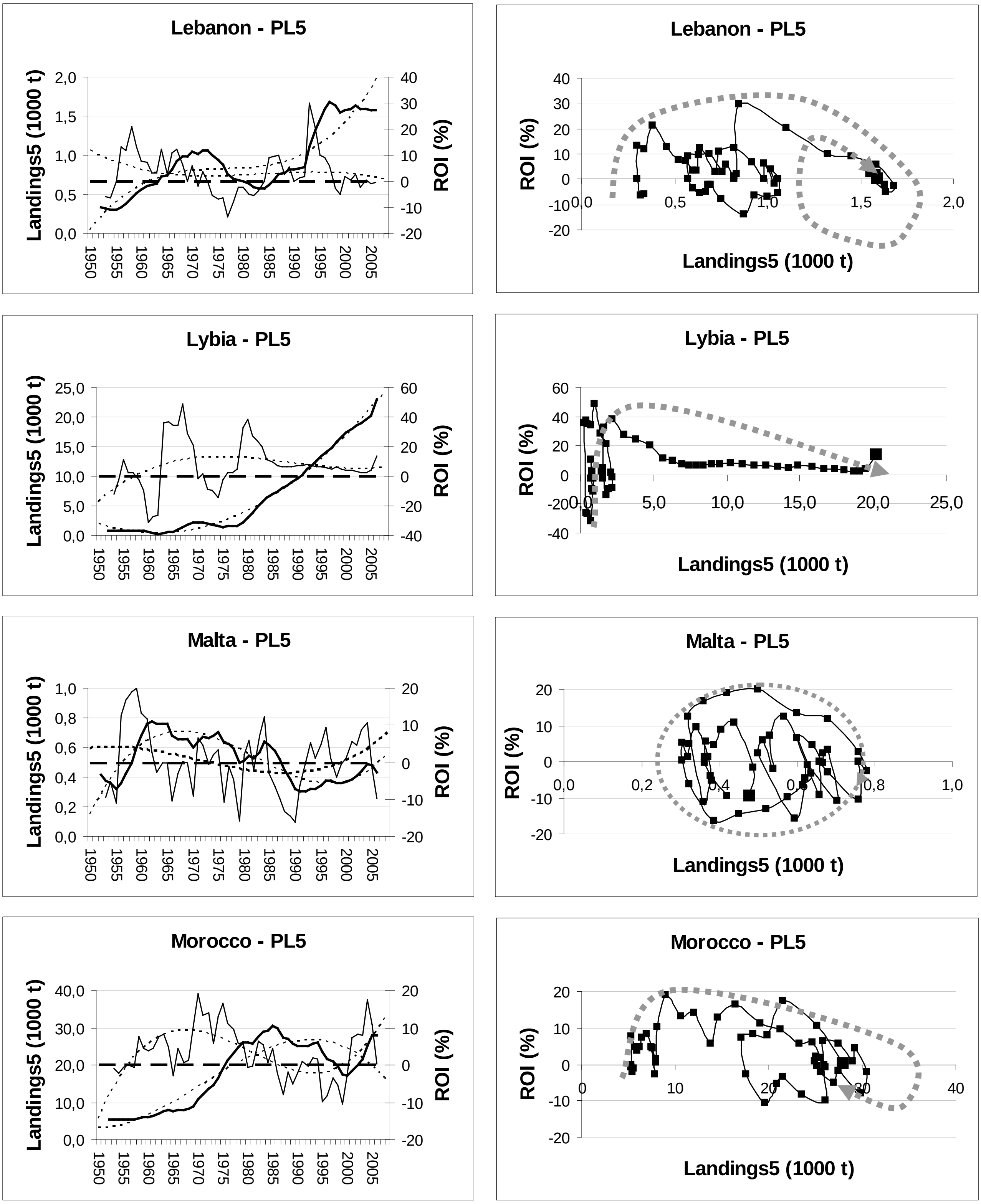
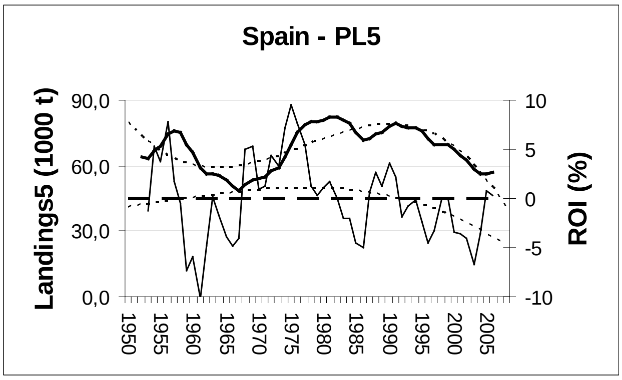
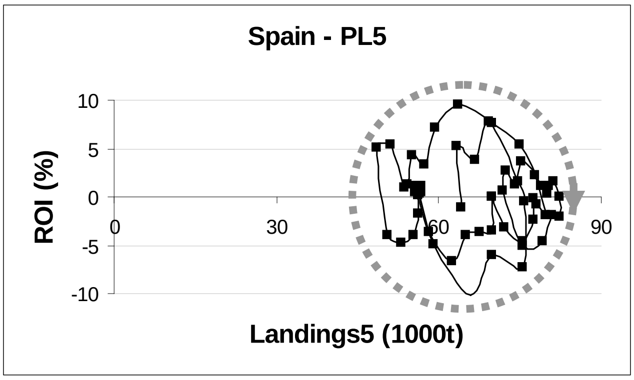
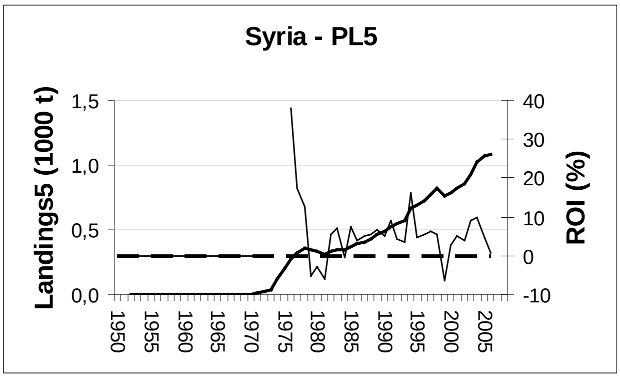
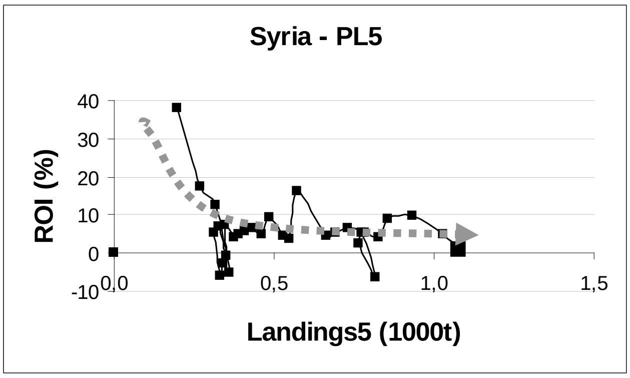


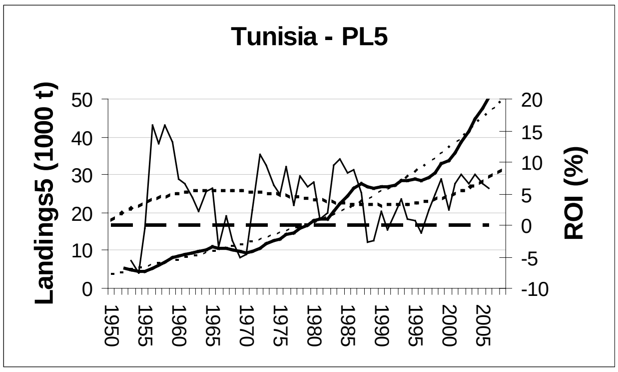
Plate 10D: Pelagic Fish. National Development patterns 1950-2008 (Continued)

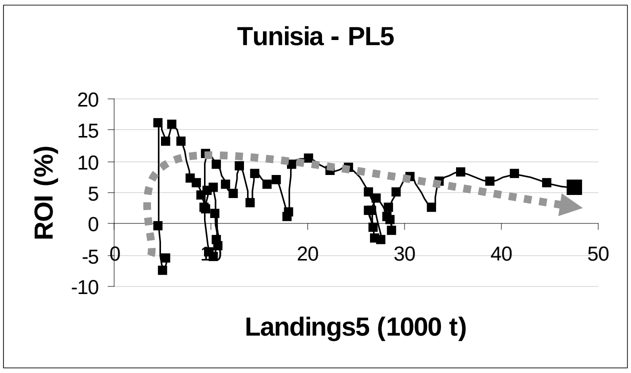


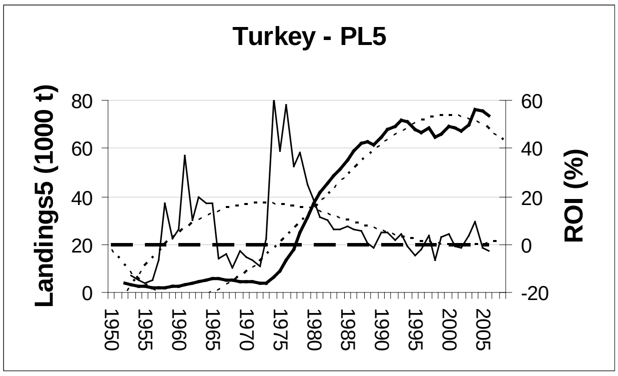












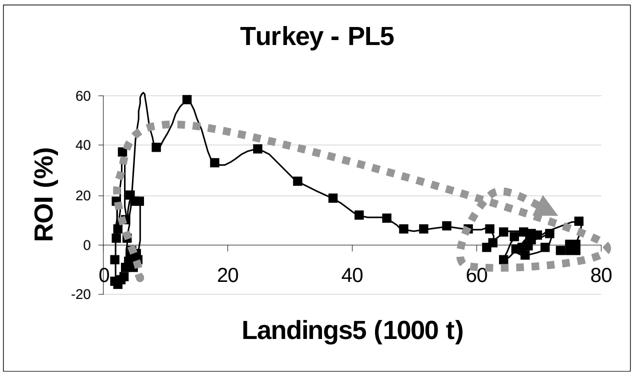
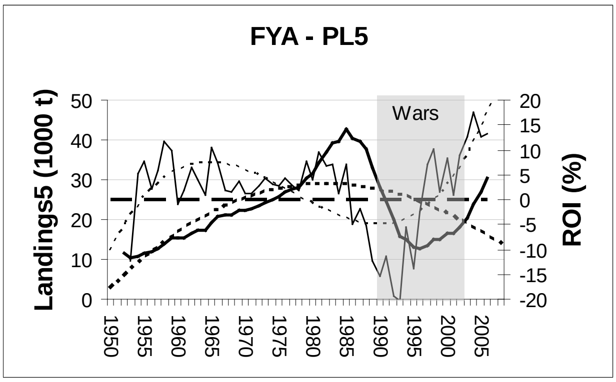
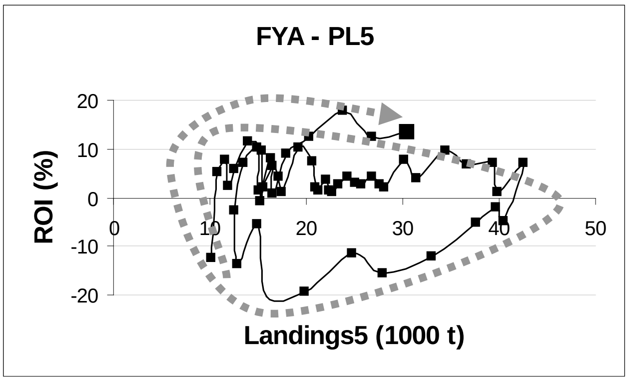
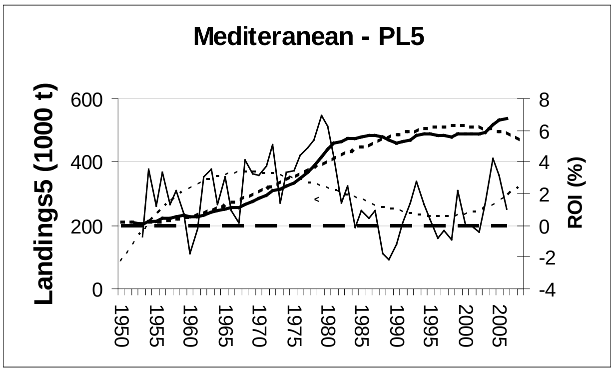


Plate 10E: Pelagic Fish. National development patterns 1950-2008 and total for the Mediterranean







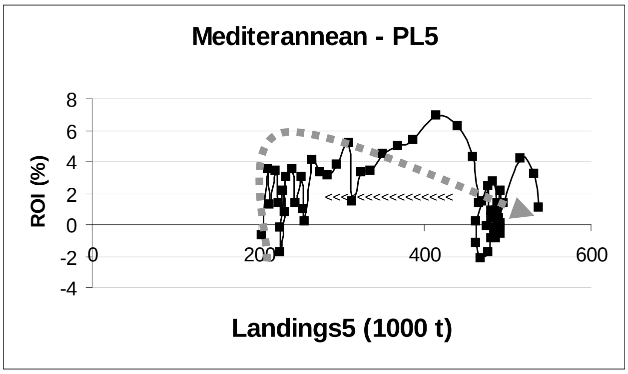


Plate 11A: Bottom Fish. National development patterns 1950-2008

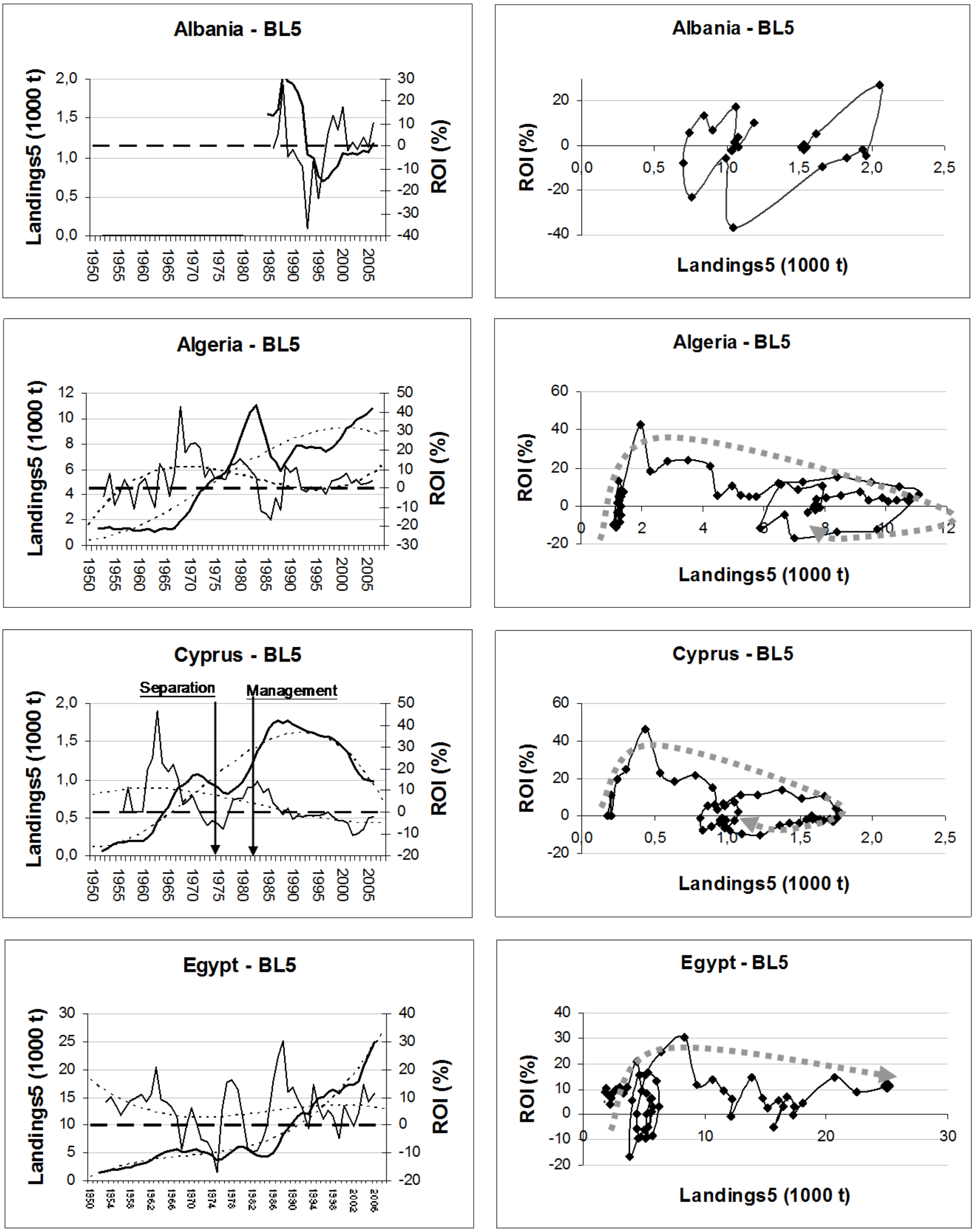
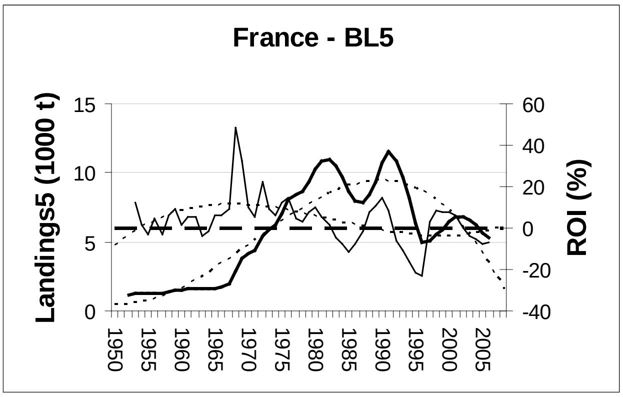
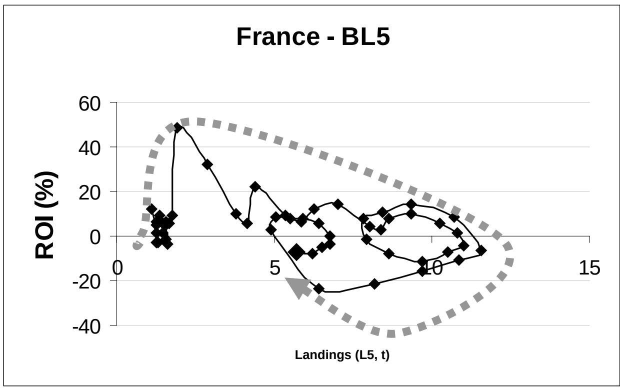
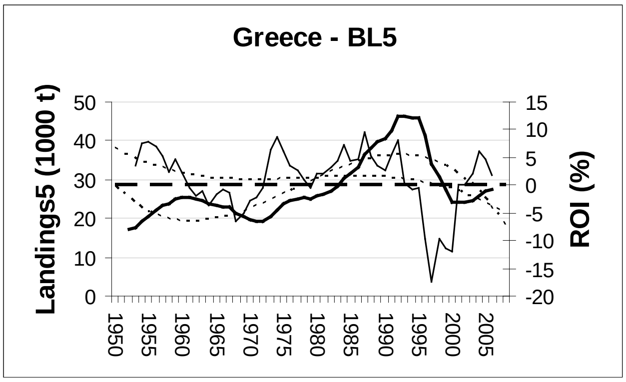
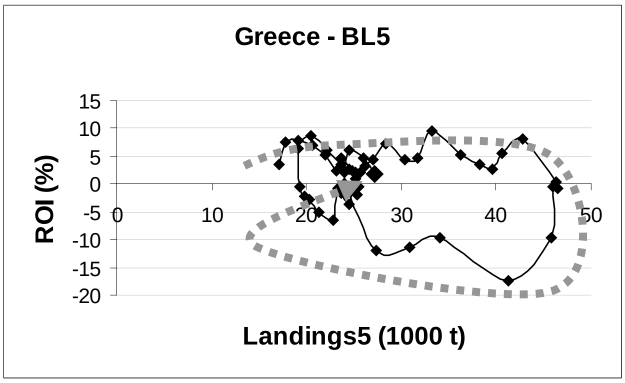


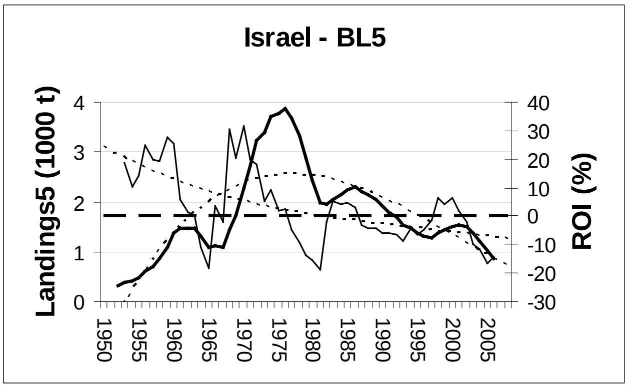
Plate 11B: Bottom Fish. National development patterns 1950-2008

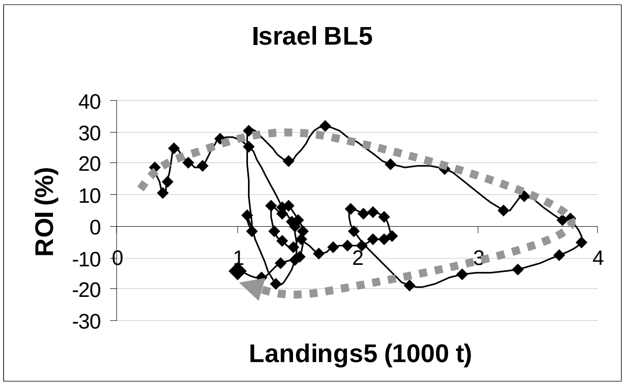


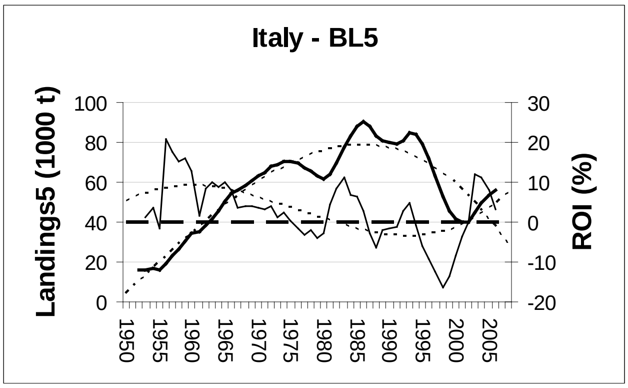












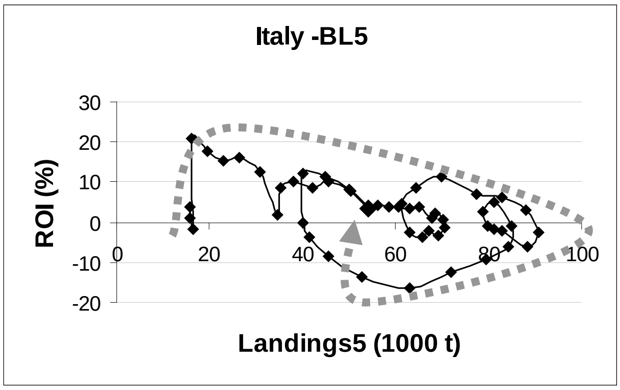


Plate 11C: Bottom Fish. National development patterns 1950-2008

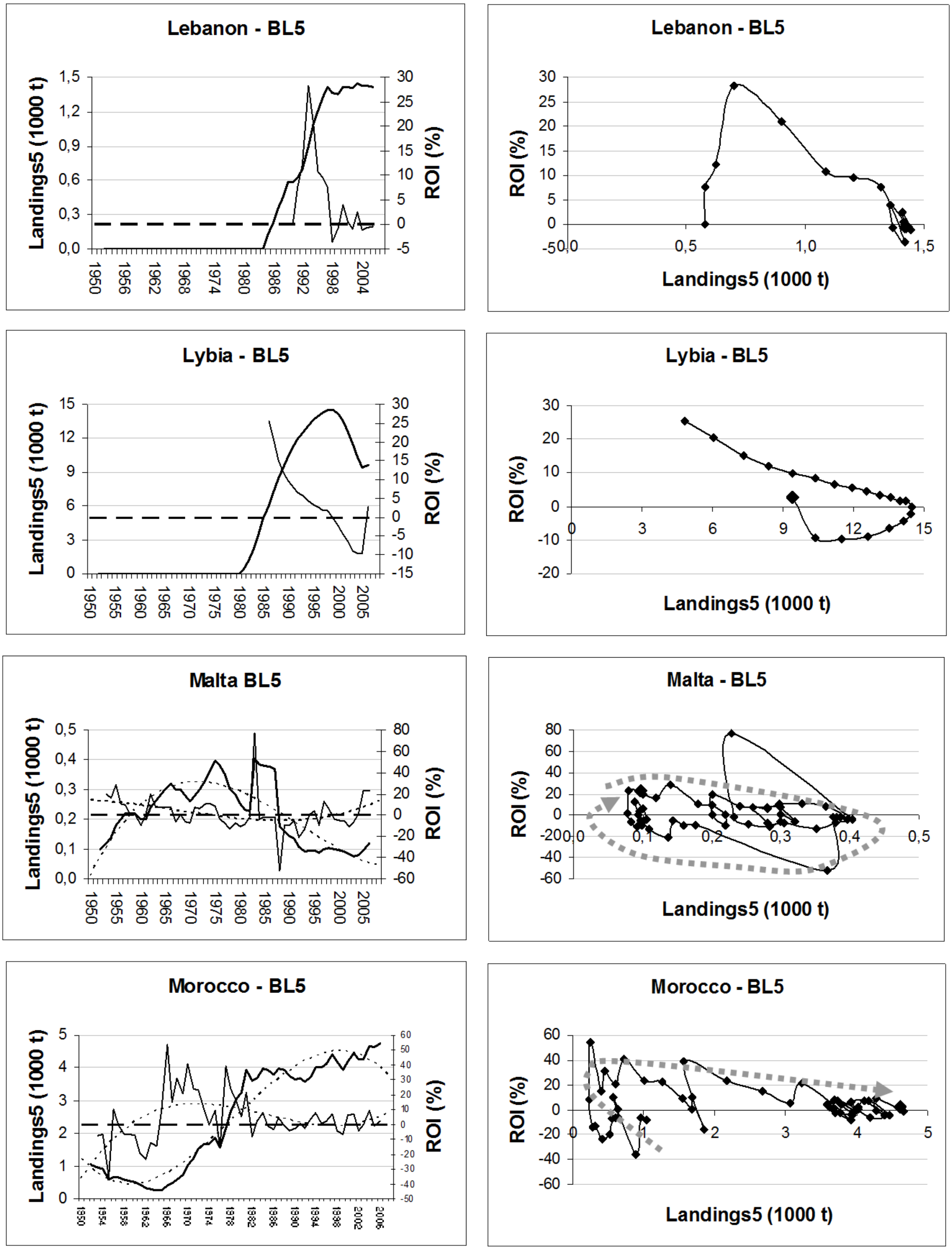


Plate 11D: Bottom Fish. National development patterns 1950-2008

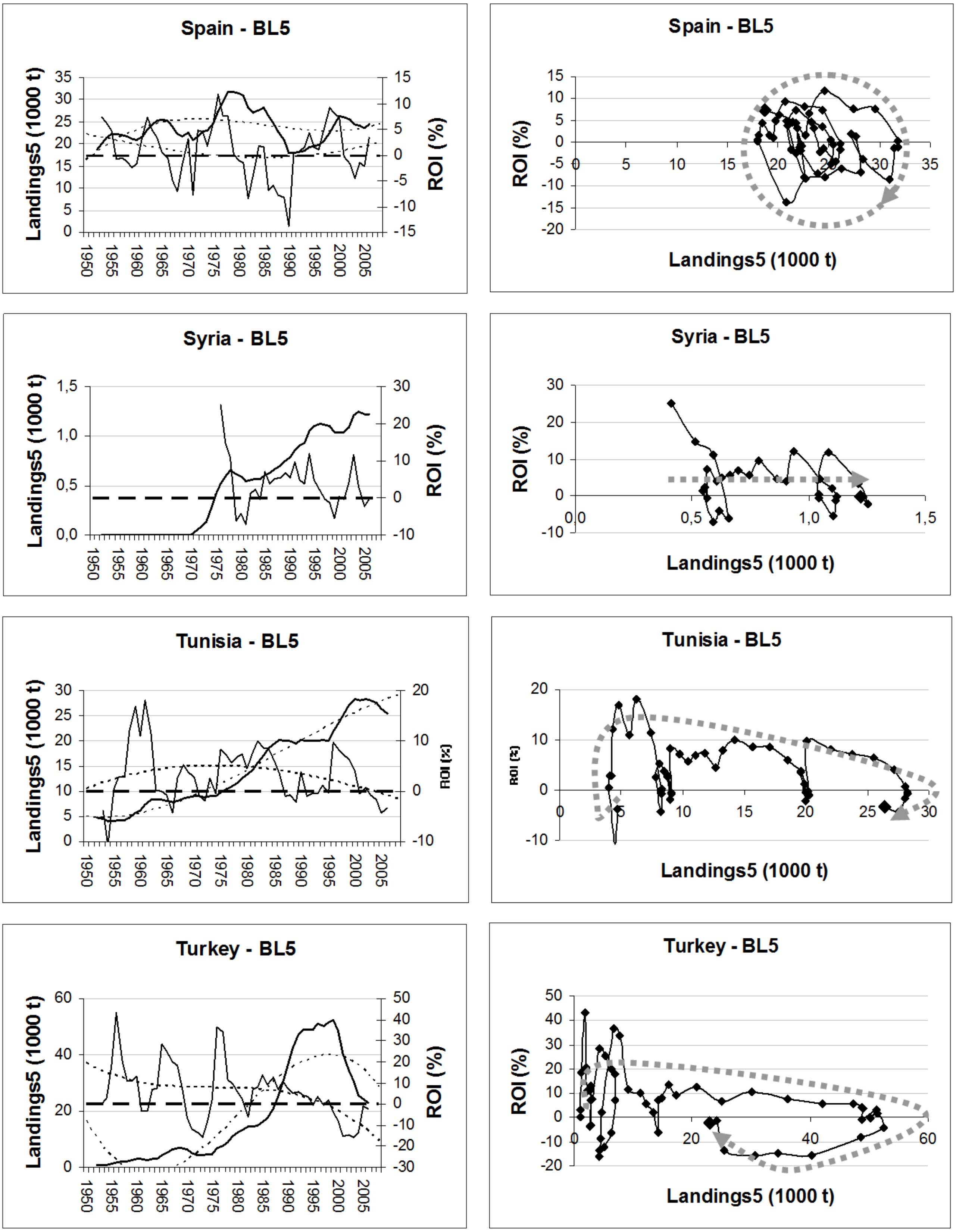
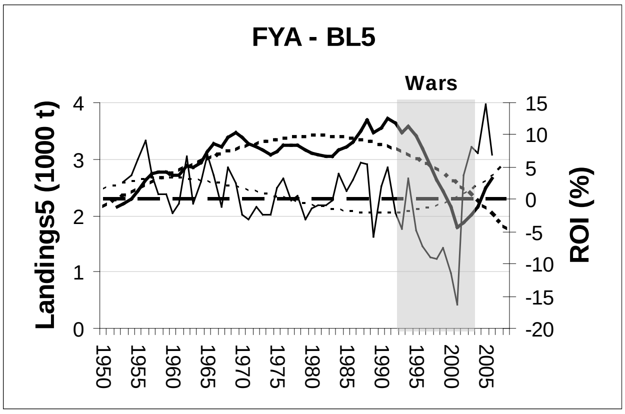
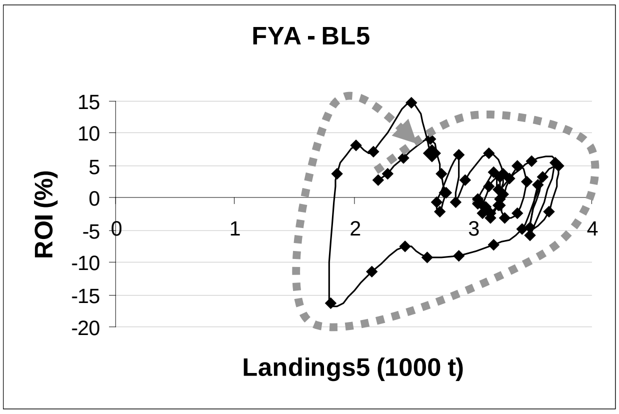
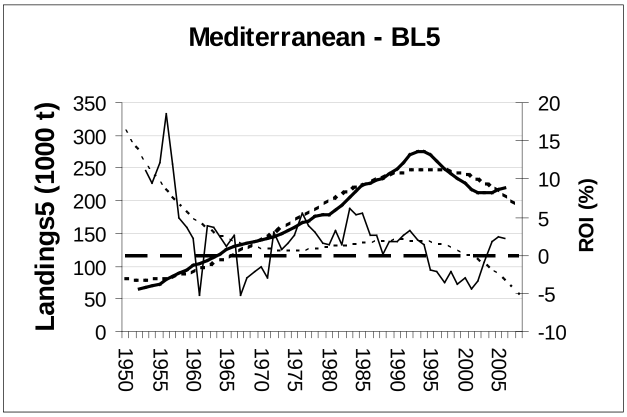


Plate 11E: Bottom Fish. National development patterns 1950-2008 and total for the Mediterranean







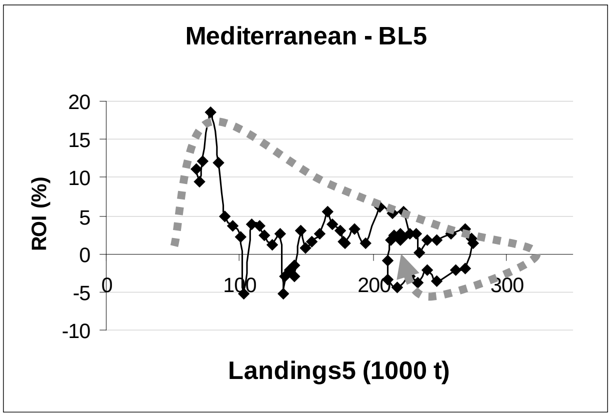


Plate 12A: Other Fish. National Development patterns 1950-2008

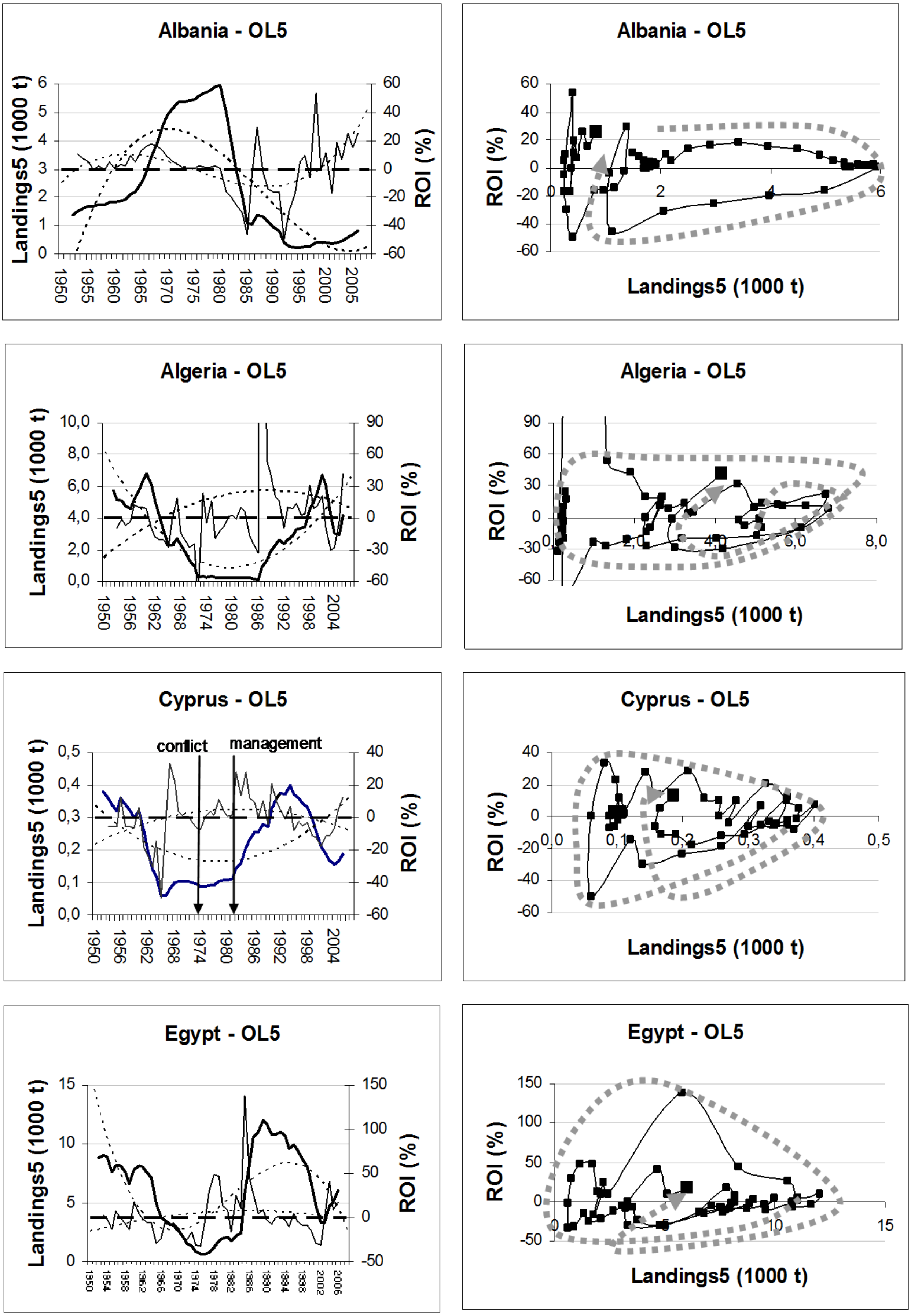


Plate 12B: Other Fish. National Development patterns 1950-2008

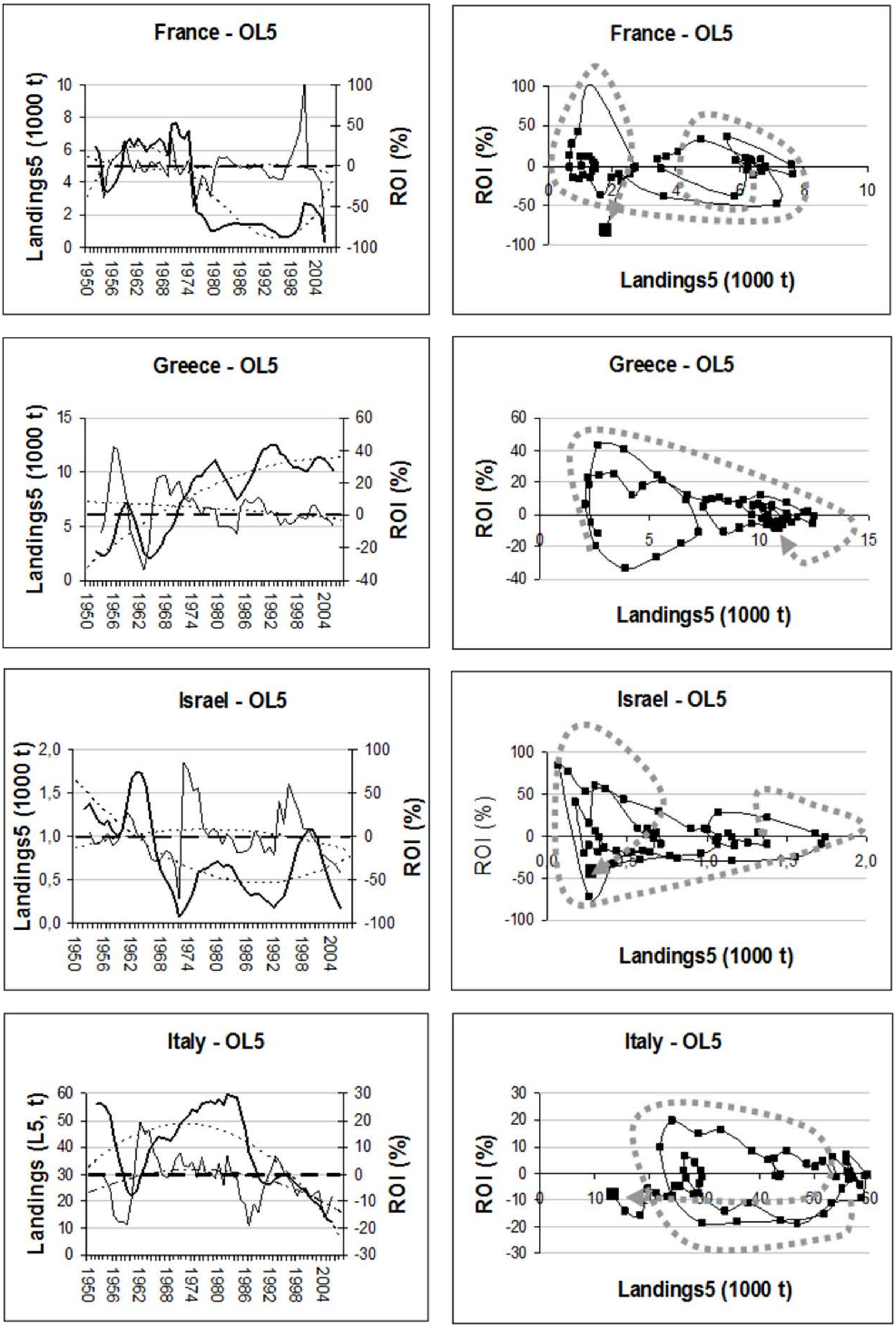


Plate 12C: Other Fish. National Development patterns 1950-2008

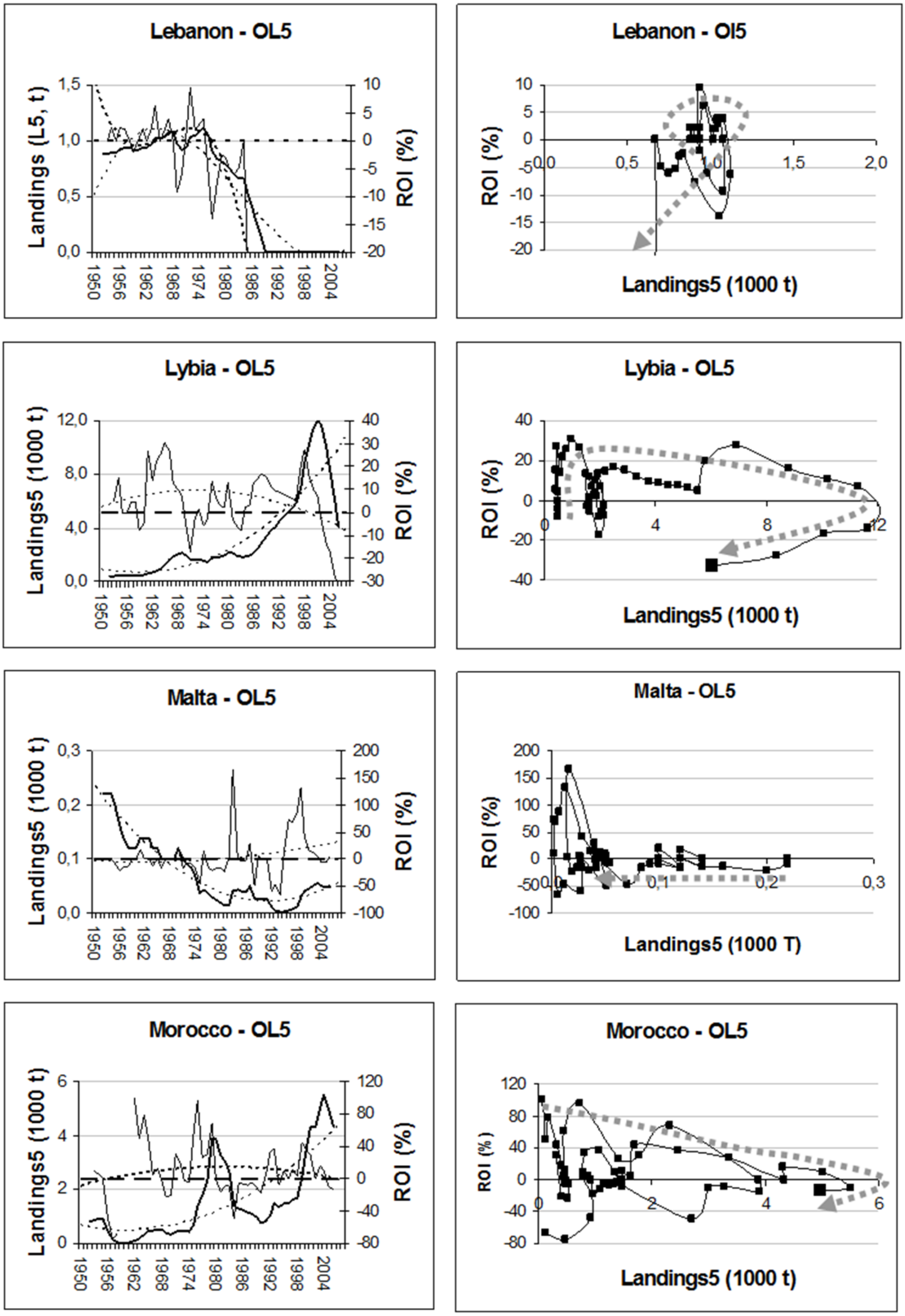


Plate 12D: Other Fish. National Development patterns 1950-2008

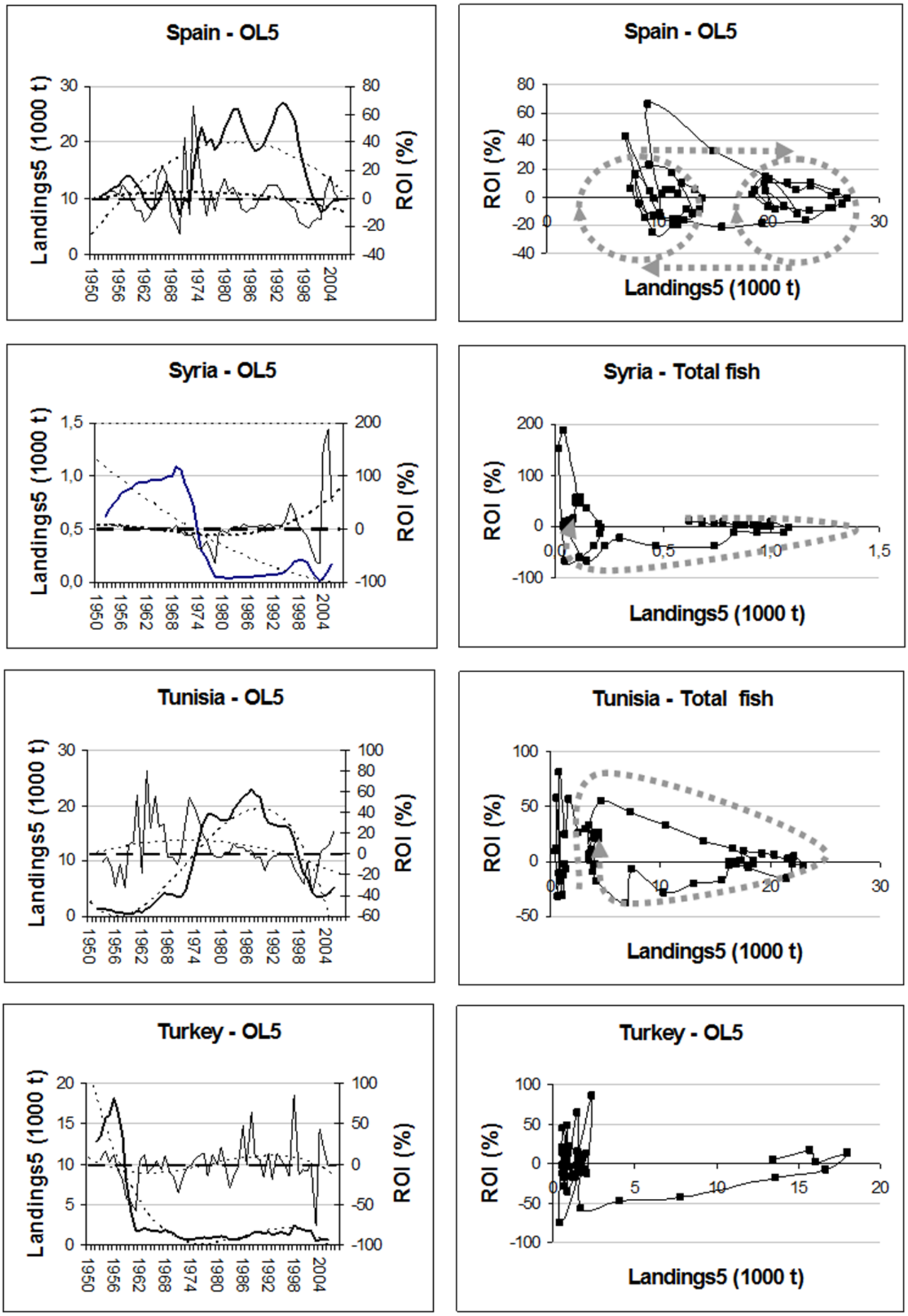


Plate 12E: Other Fish. National Development patterns 1950-2008 and total for the Mediterranean.

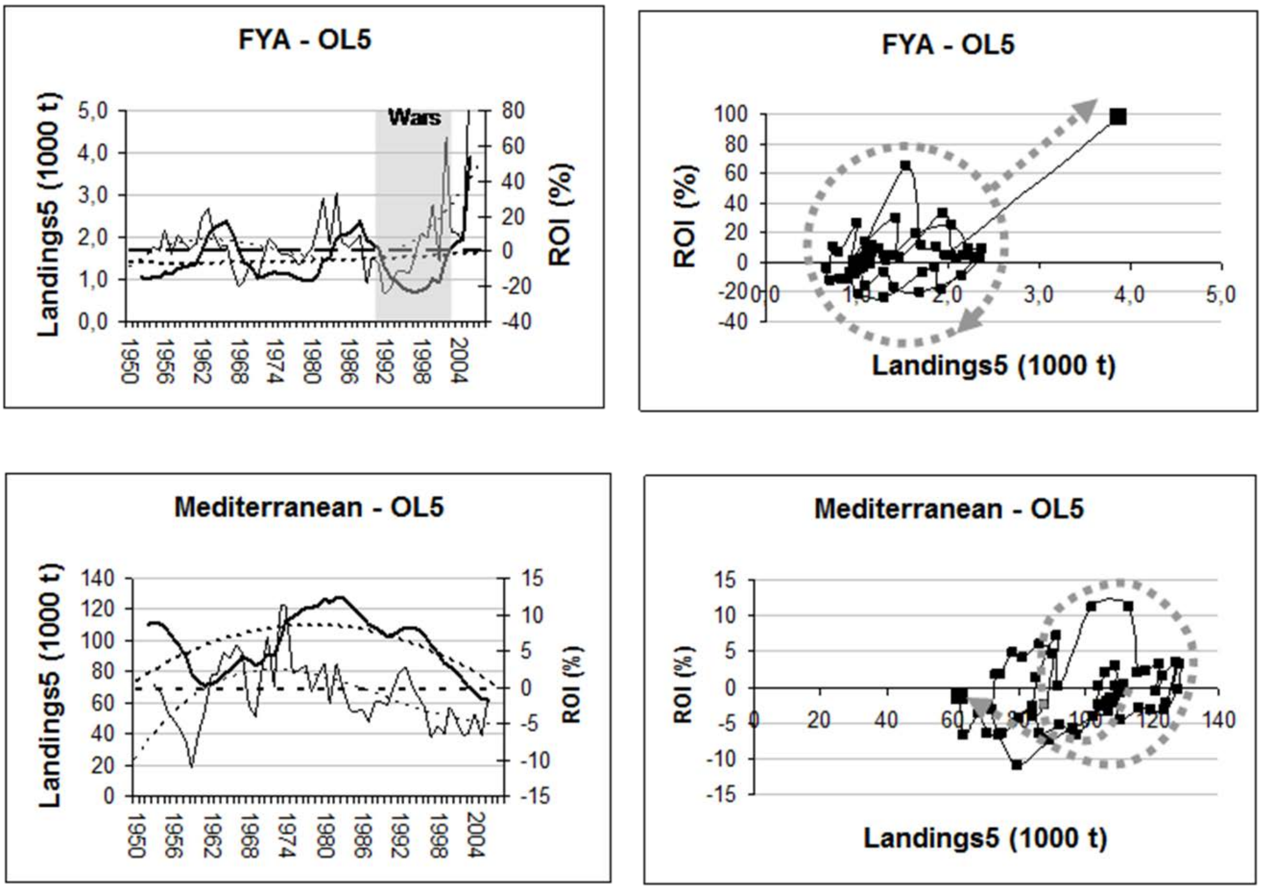


Table of Illustrations

Figures

Tables