Spatial and Temporal Data Analysis of Cephalopods Catches in Greece

Georgios K. Tegos[1]

[1]Information Technology Department, Alexander Technological Educational Institute of Thessaloniki, (A.T.E.I.TH), P.O. Box 14561, 54101 Greece, e-mail: gtegos@gen.teithe.gr

Abstract. Multidimensional Fishery Time Series database stores fishery time series data regarding different aspects of Greek fishery sector such as economical, technical, biological, space and time and it is used for carrying out sustainability and risk analysis of Cephalopods catch quantity in Greece. Economically the most important Cephalopods species Octopus seems to be sustainable for the last four years. Besides, Aegean Sea areas are more sustainable than Ionian Sea areas as it concerns biodiversity. This type of research gives the opportunity to study changes of catch quantities by species and by areas in time, which may constitute an essential tool to support decision making on sea fishery resources and related economical activities.

Keywords: time series database, sustainability, risk, biodiversity

1 Introduction

Human interest in Cephalopods is long standing. The classical civilizations of the Mediterranean had a good knowledge of the various types. Descriptions of Cephalopods can be recognized in Homer's Odyssey, Aristotle's *Historia Animalium, in* Minoan Crete and Greek and Roman cultures *as well*. Boyle and Rodhouse (2005). Cephalopods, as shown by drawings on Greek ceramics and the Aristotle's descriptions, were well known in Greece since the antiquity. Nevertheless available data concerning cephalopod fauna and biology were scanty prior to the 1990s. Despite the reduction in the quantity of cephalopods since 1996, their proportion compared to total production of marine fisheries continues to increase. Lefkaditou (2006). The share of total catch quantity of Cephalopods changes from 7 to 11% of total fish catch quantity for the period 2000-2011. Besides, the food quality of these species, especially Octopus, makes this group very important. Cephalopods exist in all marine habitats worldwide and provide a large part of the total global biomass of all marine. Clarke (1996). Scientific knowledge of cephalopod distributions and abundances is important to understand their contribution not only to ecological relationships but also to overall energy flow and transfer of materials. Piatkowski et al. (2001). Fishing pressure on marine biota has increased during the last decade. Data from the Food and Agriculture Organization of the United Nations (FAO) reveal no rise in marine catch during this period Valavanis et al. (2002) FAO statistics on cephalopod catch in the Mediterranean show no rise

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since 1988. Meaden and Do (1996). Data from the Greek National Statistical Service (GNSS) reveal the same pattern in cephalopod fisheries in the Eastern Mediterranean since 1994. FAO (2000). Since the early 90s, however, the distribution and abundance of cephalopods in the Greek Seas have started to be regularly monitored but the data have not yet been thoroughly analyzed D'onghia et al. (1992); Lefkaditou and Kaspiris (1996). The sensitivity of cephalopod species to environmental fluctuations is a potentially important factor to take into account in stock assessments and fishery management measures. It also suggests that cephalopods could act as indicators of environmental change and ecosystem conditions. Pierce et al. (2013). Evidence of overexploitation of fish stocks in the Greek seas is widespread and growing. In 2007, about 65% of the Greek stock was characterized as overfished, 32% as fully exploited and only 3% were characterized as developing; collapsed stocks were not recorded. It was concluded that the Greek fisheries are no longer sustainable and radical management measures are needed. Tsikliras et al. (2013). Ecological indicators calculated from landings data have been extensively used to evaluate the effects of fishing on marine ecosystems. However, few studies have tested the possible effects of gear and spatial aggregation of landings data on different ecological indices over a long-term period. Moutopoulos et al. (2014).

This paper aims to analyze spatial and temporal data on quantity of Cephalopods catch in Greece for the period 2000-2011. The issues of sustainability of catch quantities and risk analysis have a primary significance in this study.

2 Materials and methods

Multidimensional Fishery Time Series (FTS) database on fishery that is based on National Statistical Service database of Greece (NSSG) is the source of data for this study. FTS database stores fishery time series data regarding different aspects of Greek fishery sector as follows:

- Economical – Quantity of catch, Value of catch, Employment, Category
- Technical – Kind of fishery, Fishing tool
- Biological – Fish group, Fish species
- Space – Country, Fish area
- Time – Year, Month.

	Area_Code	Name	Measure
+	106	Gulf of Kyparissia and Gulf of Messinia	Metric tons
+	107	Gulf of Lakonia	Metric tons
+	108	Gulf of Argolida and Saronikos Gulf	Metric tons
+	109	Gulf of Korinthia	Metric tons
+	110	Gulf of S and N Evia-Gulf of Lamia	Metric tons
+	111	Pagassitikos Gulf	Metric tons
+	112	Eastem coasts of Evia and Sporades islands	Metric tons
+	113	Thermaikos Gulf and Gulf of Chalkidiki	Metric tons
−	114	Str. G.,G.of Kavala-Thassos and Sea of Thraki	Metric tons

Year/FishSpecies	Flying squid	Common squid	Poulp	Cuttle fish	Octopus
#2000	459,069	233,7203	525,736	545,5315	1272,47
#2001	364,1	82,9	365,4	475,2	1216,8
#2002	483,2	62,2	323,1	454,8	1454,5
#2003	500,3	76,2	465,5	375	1717,1
▶ #2004	419,5	58,9	327,7	394,6	1987,4
#2005	448,3	80,5	422,9	282,8	1368,2
#2006	412	73	327	263	893
#2007	500	132	513	325	1075

Fig. 1. Access to the hierarchically structured Greek fishery Time series Database

FTS database is a hierarchically structured multidimensional database. It consists of a collection of five data cubes. Onkov (2011); Tegos and Onkov (2015). Three of them concern quantity of catch by fish group and fish species, areas, kind of fishery, and fishing tools. FTS database operates with two types of tables: dimension and fact tables. Dimension tables store attributes values and relationships among tables. Fact tables contain time series data and foreign keys which refer to primary keys in the dimension tables. There is only one entry-point to each fact table of FTS database cubes. Onkov and Stoyanova (2013). The whole data set has temporal character. Data pertinent to catch quantity by areas is spatially oriented. FTS database facilitates flexible: data access, visualization, update and process.

"Quantity of catch" (in metric tons) is accounted by 18 fishing areas and each area by 71 fish species. Figure 1 presents the access to time series on catch quantity of five species in the group Cephalopods. Hierarchical data structure is obvious.

The framework (figure 2) presents the process of studying time series on quantity of Cephalopods catches. The basic operations in FTS database refer to access and extraction of: a) temporal data (time series) on quantity of Cephalopods catches by species; b) spatial time series on quantity of Cephalopods catches by areas. Consequently the computing procedures are used for applying descriptive statistics, graphical presentation of trends and extraction of information for missing catches. The results of time series processing offer the opportunity to estimate sustainability and make comparative and risk analysis of Cephalopods catches in Greece.

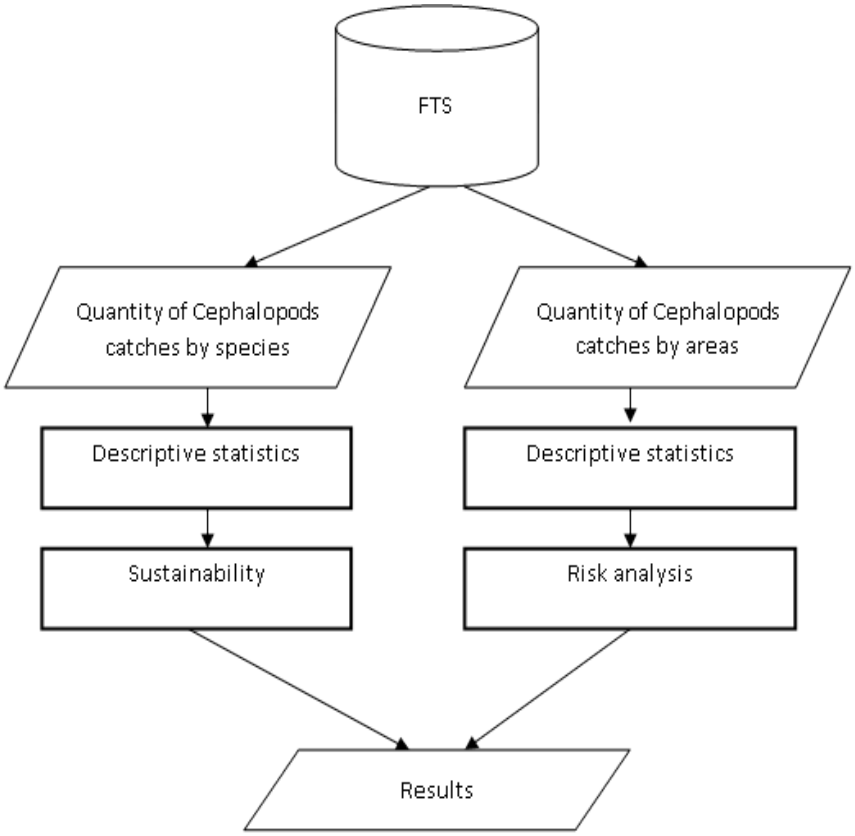

Fig. 2. Framework for studying time series on quantity of Cephalopods catches

3 Results and Discussion

According to Standard Deviation (StDev) and Coefficient of Variance (CoefVar) of descriptive statistics (Table1), it can be derived that the most unsustainable catches are those of Cuttlefish (StDev=872,6, CoefVar=40,2), while the most sustainable ones are those of Flying-squid (StDev=146,2, CoefVar=14,2). Octopus has the biggest average catch quantity - 2346,8 m^3 tons. The coefficient of variation of catch quantity for Octopus (20.2%) is much closed to the coefficient of variation for total Cephalopods catches (19,2%).

Figure 3 shows that the rapid increase of catch quantity in years 2002 and 2003 causes the unsustainability of Cuttlefish that after year 2004 is considered relatively sustainable, especially for the last 4 years (2008, 2009, 2020 and 2011) where the catch quantity is close to 1400 m^3 tons.

The general trend for Cephalopods catches seems also to be sustainable for the last 4 years after the strong decline of 2003-2008 period.

Table 1. Descriptive statistics, catches by species

Code	Cephalopods	Sum	Average	StDev	CoefVar /%/
65	Flying squid	12354,2	1029,5	146,2	14,2
66	Common squid	7782,3	648,5	222,3	34,3
67	Poulp	8785,8	732,2	165,4	22,6
68	Cuttle fish	26042,9	2170,2	872,6	40,2
69	Octopus	28161,8	2346,8	473,7	20,2
	Total	83127,0	6927,3	1326,9	19,2

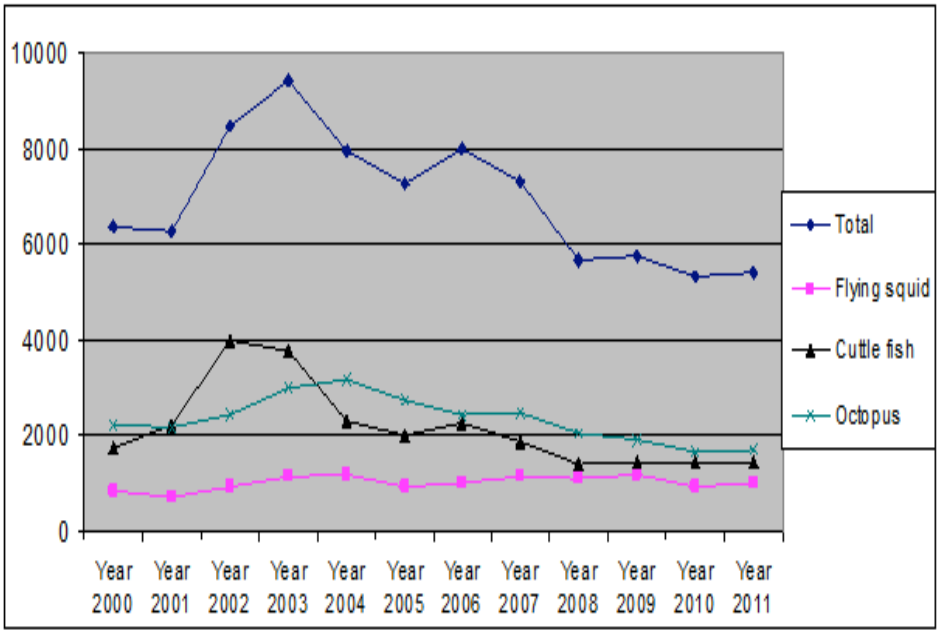

Fig. 3. Quantity of cephalopods catches in Greece

It is possible to view some interesting facts concerning catches by areas and species for the studied time period (table 2). The catches of 0,3 m^3 tons for Poulp and 13,6 m^3 tons for Flying squid in the Gulf of Lakonia area are very low. The lowermost values for total catches of Cephalopods are registered in Gulf of Kyparissia and Gulf of Messinia (151,5 m^3 tones) as well as in Gulf of Lakonia

(118,4 m^3 tones). Economically the most important Cephalopods species Octopus has the maximum value 13009,5 m3 tones in Str. G.,G.of Kavala-Thassos and Sea of Thraki.

Table 2. Total catch quantities by areas and by species for the period 2000-2011

Area name	Flying squid	Common squid	Poulp	Cuttle fish	Octopus	Total
Coasts of Ipiros and Kerkyra	58,3	275,0	157,1	195,3	164,1	**849,7**
Amvrakikos Gulf and coasts of Lefkada island	27,3	283,3	29,8	80,3	84,8	**505,5**
Coasts of Kefalonia, Zakynhos and Gulf of Patra	952,4	1185,1	758,4	965,6	832,5	**4694,0**
Gulf of Kyparissia and Gulf of Messinia	17,6	58,5	7,3	41,1	27,0	**151,5**
Gulf of Lakonia	13,6	42,5	0,3	41,3	20,8	**118,4**
Gulf of Argolida and Saronikos Gulf	919,1	548,9	316,8	335,8	693,2	**2813,9**
Gulf of Korinthia	186,7	100,6	85,0	61,2	70,7	**504,3**
Gulf of S and N. Evia-Gulf of Lamia	924,1	631,9	514,6	698,4	70,7	**2839,7**
Pagassitikos Gulf	109,9	42,2	10,7	65,2	167,3	**395,4**
Eastem coasts of Evia and Sporades islands	497,5	116,8	140,9	103,7	177,7	**1036,6**
Thermaikos Gulf and Gulf of Chalkidiki	2261,4	721,1	1328,5	12770,5	6730,7	**23812,3**
Str. G.,G.of Kavala-Thassos and Sea of Thraki	4757,5	1131,1	4168,9	3825,4	13009,5	**26892,4**
Islands of Lesvos, Chios Samos and Ikaria	516,2	275,9	218,4	716,5	391,7	**2118,7**
Dodekanissos	54,4	194,2	46,0	73,6	590,6	**958,7**
Kyklades	730,2	924,9	663,6	690,1	602,7	**3611,5**
Kriti	315,6	350,8	337,8	625,9	195,2	**1825,4**

Regarding “Number of years without catches” for Cephalopods (Table3) results can be analyzed from both Economical and Biological perspectives. Economical view may concern Skippers, fishermen, local and national wealth etc. and on the other hand Biological view that can be related to Ecological one as well, may refer to lack of sustainability, risk of depletion and risk of extinction of fish species. The

results concerning areas shows that Areas of "Gulf of Kyparissia and Gulf of Messinia" and "Gulf of Lakonia" include the highest risk of all areas since the percentage of years without catches is 38,36 and 23,29, respectively. Especially for Flying Squid and Cuttlefish, in the first area, the percentage is much bigger since in 8 out of 12 years catches are missing while for species Poulp in the second area there are catches for only two years.

Table 3. Number of years without catches

	Cephalopods						
Area name	Flying squid	Common squid	Poulp	Cuttle fish	Octopus	Total	%
Coasts of Ipiros and Kerkyra	3	0	0	0	0	**3**	4,11
Amvrakikos Gulf and coasts of Lefkada island	2	0	0	2	1	**5**	6,85
Coasts of Kefalonia, Zakynhos and Gulf of Patra	0	0	0	0	0	**0**	0
Gulf of Kyparissia and Gulf of Messinia	8	4	8	4	4	**28**	38,36
Gulf of Lakonia	3	0	10	0	4	**17**	23,29
Gulf of Argolida and Saronikos Gulf	0	0	0	0	0	**0**	0
Gulf of Korinthia	0	1	2	3	3	**9**	12,33
Gulf of S and N. Evia-Gulf of Lamia	0	0	0	0	0	**0**	0
Pagassitikos Gulf	0	2	5	1	0	**8**	10,96
Eastem coasts of Evia and Sporades islands	0	0	0	0	0	**0**	0
Thermaikos Gulf and Gulf of Chalkidiki	0	0	0	0	0	**0**	0
Str. G.,G.of Kavala-Thassos and Sea of Thraki	0	0	0	0	0	**0**	0
Islands of Lesvos, Chios Samos and Ikaria	0	0	0	0	0	**0**	0
Dodekanissos	0	0	2	1	0	**3**	4,11
Kyklades	0	0	0	0	0	**0**	0
Kriti	0	0	0	0	0	**0**	0
Total	**16**	**7**	**27**	**11**	**12**		
%	21,92	9,59	36,99	15,07	16,44		

Pertinent to Totals (Sum) in Table1 the most important species of Cephalopods, economically, are Cuttlefish (26042,9 metric tons) which is widespread in almost all fishing areas (Table3) even though it lacks of sustainability and Octopus (28161,8 metric tons) that is relatively sustainable and widespread as well.

Comparing Aegean see areas to Ionian see ones, according to Table 3, it is obvious that the 1st one is more sustainable as it concerns biodiversity.

4 Conclusion

This type of research gives the opportunity to study changes of catch quantities by species and by areas in time. It may constitute an essential tool to support decision making on sea fishery resources and related economical activities.

Scientists as marine biologists, ecologists, economists etc. have to take into consideration such studies and advise people in charge of governments and local authorities to take measures for sustainable fishery as well as social measures for supporting people that will probably be out of work for a certain period of time, in accordance with their suggestions.

If all these parties work in co-operation, the sea fishery sector will be sustainable and continue to provide the nutritious sea fish to the people, jobs to fishermen and support to local and national economies.

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