about their report, or me (as editor) for the same sin? It seems the lesson is that one should publish one's new ideas, lest others get the same idea, and publish it.

Tony Pitcher and Ernest Naylor are obviously right: students of fishery biology should all learn taxonomy, gear technology, fish behavior, physiology, fish diseases, aging techniques, field techniques, do stomach content analysis, solve difficult problems of real biology in the laboratory, get their feet wet, learn electron microscropy, you name it; numeracy should not be overrated.

John Gulland's letter is a bit embarassing to me because:

(i) My footnote to Celeste Philbrick's article was not meant to suggest "that this new study had removed this problem". Rather, (Celeste may forgive me for this) I put the footnote, and the cross reference to Dalzell's article for precisely the *opposite* reason: because I did not believe that the problem had been resolved and because Dalzell had mentioned the need to conduct otolith studies to resolve the problem of growth estimation in *Selar crumenophthalmus.*

(ii) I tend to emphasize with my colleagues and students, in my writings and in fact everywhere I can that fishery scientists should publish the length-frequency upon which their ELEFAN or other length-based analyses are based (see e.g., contribution in FAO Fish. Rep. 389). Sometimes though, the manuscripts I receive do not include those. So I don't know how to respond.

Multivariate Analysis and Trends of the Greek Fishery

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Introduction

In Greece, where the total length of coastline is over 15,000 km, fishery production plays an important role in the national economy. In recent years, this production has levelled off at 110,000 t, in contrast to the gradual rise in fishing effort, indicating that fisheries resources, especially the demersal ones, are overfished. Greek production is inadequate and imports of fishery products are well over 30,000 t/year. Hence, the need for rational management is urgent. In this context, an attempt has been made by the author and his colleagues to assess the Greek fisheries by means of global production models, trend lines, cluster and ordination analysis, ARIMA times series models and spectral analysis (Stergiou 1986a, 1986b, 1986c, 1986d, 1986e, 1986f, 1987, 1988a, 1988b, in press (a), in press (b) , in press (c), in press (d), unpubl., Stergiou and Zouroudis 1986; Stergiou and Stergiou 1987; Stergiou and Panou 1987; Stergiou and Christou 1988; Stergiou et al. 1989) performed on statistical data collected by the National Statistical Service of Greece. In this note, the species composition by major fishing sub-area in Greek waters is examined for 1982-1985 using multidimensional scaling. Trends in the fishery are also reviewed.

Materials and Methods

Fishery statistics for Greek waters have been maintained on a monthly basis since January 1964 by the Statistical Service of Greece. For a better evaluation of the available data, Greek waters have been divided into 16 fishing sub-areas. Data are collected for each fishing vessel separately through the local custom authorities. For each vessel, a statistical questionnaire is provided showing the quantity of fish caught during the previous month (or that the vessel did not operate). (Catches from inland waters and the sport fisheries are not included in the grand total, and neither, since 1969, are the catches of the small ringnetters, drifters and liners, with engine horsepower less than 19 hp).

The data reported upon here are annual catches of 26 species (or group of species) in the 16 fishing sub-areas in Greek waters for 1982-1985, gathered from the Bulletins of the National Statistical Service of Greece (1985-1987). Multidimensional scaling was based on Euclidean distance.

Results and Discussion

Total mean catch during 1982-1985 amounted to 84,475 t. Fish made up 95% of the total catch,

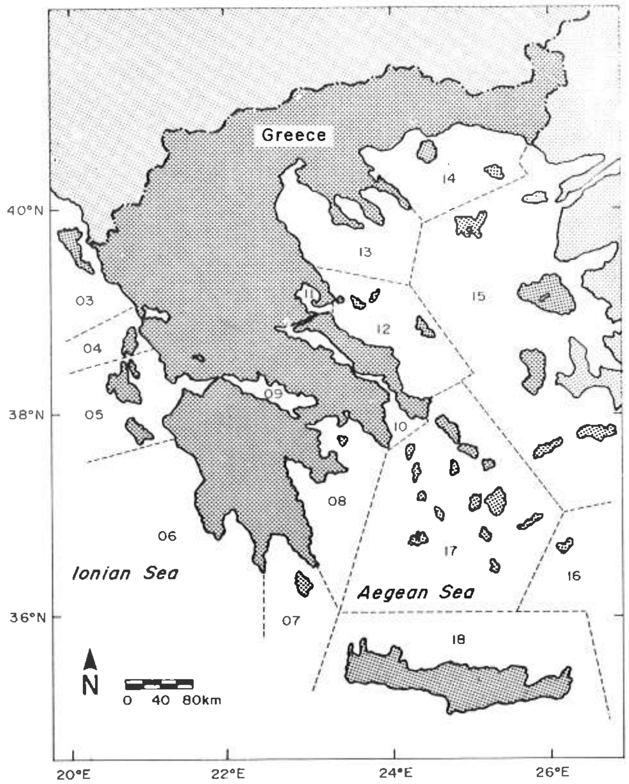

Fig. 1. Map of Greek waters, showing fisheries statistical areas 03-16 (areas 01 and 02 (not shown) refer to the Atlantic Ocean and North Africa, respectively).

cephalopods 3% and crustaceans 2%. With respect to fish, the pelagic species *Engraulis encrasicholus* and *Sardina pilchardus* dominated, representing 17.9% and 13.2% of the mean total catch, respectively. In addition, the pelagic species *Trachurus* sp., *Spicara smaris*, *Boops boops*, *Scomber japonicus*, *Mugil cephalus* and the demersal species *Merluccius merluccius* made up 10%, 8.4%, 8.2%, 3.2%, 2.3% and 3%, respectively. Of the remaining species, none contributed more than 2% (Table 1).

Multidimensional scaling performed on the [16 fishing sub-areas x 26 species] matrix (not shown here) indicated three distinct groups of fishing sub-areas (Fig. 2A): Group I (sub-area 13), Group II (sub-areas 8, 12, 14) and Group III (sub-areas 3, 4, 5, 6, 7, 9, 10, 11, 15, 16, 17, 18). The adequacy of the plot is suggested by the Shepard diagram (Fig. 2B), a rather tight scattergram of distances against input similarities or dissimilarities. Mean annual catches and proportions of catches by fishing sub-area, indicated by multidimensional scaling, and major species (or group of species) for 1982-1985 are shown in Table 1.

Group I

Sub-area 13 made up 27.6% of the total mean catch in Greek waters. *E. encrasicholus* dominated the catches, representing 26.6% of the total catch. *S. pilchardus*, *Trachurus* sp. and *Mugil cephalus* made up 13.3%, 6.3% and 6.4% respectively. *M. merluccius* and *B. boops* made up 2.6% and 2.1%, respectively, while all remaining species each contributed less than 2% (Table 1).

Group II

Sub-areas 8, 12 and 14 made up 36.2% of the total mean catch in Greek waters. In this group, *E. encrasicholus* dominated the catches, representing 22.1%. *S. pilchardus* and *Trachurus* sp. made up 18.3% and 14.5% accordingly, while *B. boops*, *S. smaris*, *M. merluccius* and *Scomber japonicus* made up 6.2%, 4.9%, 3.7% and 2.2% accordingly. All remaining species each contributed less than 2% (Table 1).

In sub-area 8, *Trachurus* sp. dominated the catches, representing 23.5%, while *S. pilchardus*, *E. encrasicholus*, *B. boops* and *S. smaris* made up 16.5%,

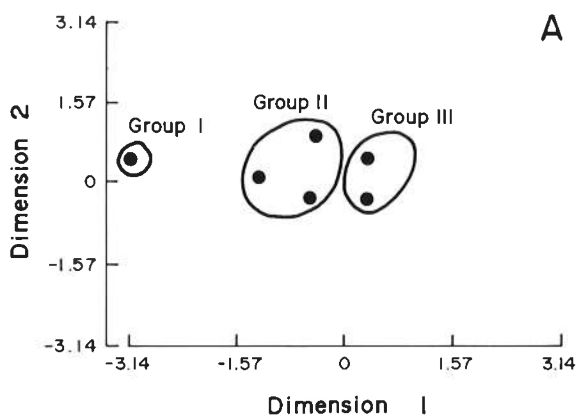

Fig. 2A. Multidimensional scaling of species-specific catches (26 groups) from 16 Greek fishing sub-areas, leading to identification of 3 groups of sub-areas (see also Table 1).

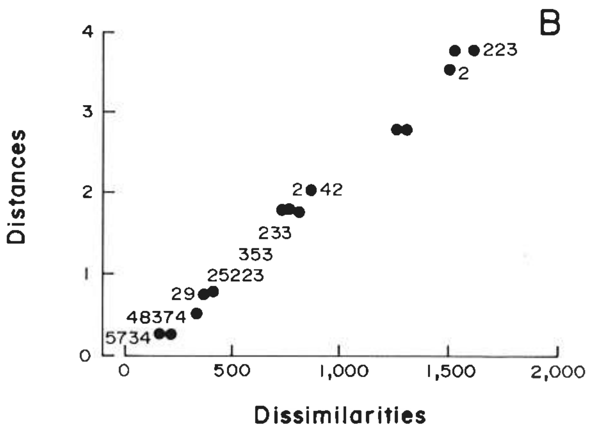

Fig. 2B. Shepard diagram of distances vs. dissimilarities of fisheries catches from the same 16 sub-areas. Note tight association for both A & B (the numbers refer to the number of overlapping sub-areas).

Table 1. Species composition of the fishery in Greek waters (1982-1985) by major group identified by means of multidimensional scaling.[a]

	Total catch	%	Group III Catch	%	Group I Catch	%	Group II Catch	%
Engraulis encrasicholus	15,107	17.9	2,113	6.9	6,214	26.6	6,780	22.1
Sardina pilchardus	11,115	13.2	2,407	7.9	3,101	13.3	5,607	18.3
Spicara smaris	7,114	8.4	5,409	17.7	198	0.8	1,507	4.9
Trachurus sp.	8,542	10	2,618	8.6	1,473	6.3	4,452	14.5
Boops boops	6,891	8.2	4,491	14.7	495	2.1	1,905	6.2
Scomber japonicus	2,712	3.2	1,594	5.2	442	1.9	676	2.2
Merluccius merluccius	2,541	.0	783	2.6	617	2.6	1,140	3.7
Mugil cephalus	1,972	2.3	207	0.7	1,485	6.4	280	0.9
Mullus surmuletus	1,584	1.9	1130	3.7	128	0.5	326	1.1
Mullus barbatus	1,502	1.8	605	2.0	366	1.6	531	1.7
Micromesistius poutassou	821	1.0	176	0.6	402	1.7	244	0.8
Pagellus erythrinus	503	0.6	346	1.1	13	0.1	144	0.5
Spicara flexuosa	499	0.6	242	0.8	120	0.5	137	0.4
Lophius sp.	469	0.6	38	0.1	377	1.6	53	0.2
Spicara maena	383	0.5	185	0.6	57	0.2	142	0.5
Merlangius merlangus	361	0.4	17	0.1	221	0.9	124	0.4
Diplodus sargus	357	0.4	241	0.8	38	0.2	78	0.3
Scomber scombrus	357	0.4	44	0.1	160	0.7	153	0.5
Diplodus annularis	230	0.3	48	0.2	144	0.6	39	0.1
Belone sp.	209	0.2	140	0.5	16	0.1	53	0.5
Sparus aurata	166	0.2	75	0.2	41	0.2	50	0.2
Gurnards	107	0.1	52	0.2	27	0.1	28	0.1
Dicentrarchus sp.	90	0.1	16	0.1	67	0.3	7	0.0
Zeus faber	73	0.1	35	0.1	9	0.0	29	0.1
Other fish	16,563	19.6	6,290	20.6	5,488	23.5	4,785	15.6
Cephalopods	2,532	3.0	738	2.4	971	4.2	823	2.7
Crustaceans	1,676	2.0	458	1.5	662	2.8	555	1.8
	84,475	100	30,495	100	23,330	100	30,650	
			36.1		27.6		36.3	

[a] See text for definition of Groups I, II and III

11.3%, 10% and 9.9% respectively. *M. merluccius* made up 3% of the total whereas all remaining species each contributed less than 2% (Table 1). In sub-area 12, *E. encrasicholus* dominated by far, representing 42.8%; *S. pilchardus, Trachurus* sp., *B. boops, S. smaris* and *M. merluccius* made up 12.9%, 12.6%, 6.4%, 3.1% and 3.2%, respectively; *Trachurus sp., M. merluccius, Scomber japonicus, B. boops* and *Mullus barbatus* made up 8.1%, 4.6%, 3.2%, 3% and 2.2%, respectively. All remaining species each contributed less than 2%.

Group III

Sub-areas in Group III made up 36.1% of the total mean catch in Greek waters. Species composition in this group differed greatly from those of Group I and II. *S. smaris* and *B. boops* were the dominant species, representing 17.7% and 14.7 respectively; *S. pilchardus, Trachurus* sp., *E. encrasicholus, S. japonicus, M. merluccius, M. surmuletus* and *M. barbatus* made up 7.9%, 8.6%, 6.9%, 5.2%, 2.6%, 3.7% and 2% accordingly. All remaining species each contributed less than 2% (Table 1).

Trends

Sub-areas 8, 12, 13 and 14 made up 63.9% of the total mean catch (Table 1). The relatively extended continental shelf together with the favorable type of sediment and weather conditions contributed greatly to development of the trawl and purse seine fisheries in these sub-areas. In addition, these sub-areas, with the exception of sub-area 12, are characterized by high euphtrophication levels; nutrients amount (Friligos et al. 1988) and chlorophyll a (Friligos and Karydis 1988) are many times higher than those in the open Aegean and Ionian Sea (Friligos and Karydis 1988; Friligos et al. 1988).

The use of global production models revealed that cephalopods (Stergiou, in press (d), Stergiou and Christou 1988), gadoids (Stergiou and Panou 1987) and mullidae (Stergiou, unpubl.) are strongly overfished; the pelagic resources are more or less near equilibrium (Stergiou 1986d). Strict monitoring of the pelagic fisheries is essential due to widespread changes in the relative abundance of the main pelagic species, especially pilchard (sardines) and anchovy. This has been documented for various areas in the Mediterranean Sea [coast of Morocco at Castellon, Spain, in the Spanish Alboran, the Algiers, the Adriatic Sea, and in Greek waters (Stergiou 1986e, in press (c), in press (d)]. The anchovy/pilchard catch ratio in Greek waters exhibited strong cyclic variation during 1964-1982; overall, it has increased from 0.42 in 1964 to 1.15 in 1982 (Stergiou 1986e) and 1.53 in 1985 (Stergiou, unpubl.). This was attributed to both the fluctuating oceanographic conditions and to the fact that in recent years, purse seine fishing in Greece has been anchovy-oriented rather than pilchard-oriented due to the higher price of the former (Stergiou 1986e).

Accurate forecasts one or two years in advance will be of great importance to resource managers, fishermen and market in planning and decision-making. ARIMA time series models have been successful in forecasting sardine (1989b) and anchovy monthly (Stergiou, unpubl.) 12 months in advance.

Finally, there is the question of climatic change and short term periodicity in fish populations. The catches of *M. merluccius*, *Pagellus erythrinus*, *E. encrasicholus* (Stergiou 1986b), *M. barbatus*, *M. surmuletus*, scorpionfish (Stergiou and Zouroudis 1986) and cephalopods (octopods, cuttlefish and squids) (Stergiou 1987) during 1928-1939, a period of minimal fishery pressure, were found to be significantly correlated with coastal air temperature in northern Greece. Yet, spectral analysis of sardine (Stergiou 1988a) and anchovy (Stergiou, unpubl.) monthly catches during 1964-1985 revealed a periodicity of 3-4 and 5-6 years. The factors which generate this periodicity of recruitment remain to be elucidated.

References

Friligos, N. and M. Karydis. 1988. Nutrients and phytoplankton distributions during spring in the Aegean Sea. Vie et Milieu 38:133-143.

Friligos, N., R. Psillidou and E. Chatzigeorgiou. 1988. Oxygen deficient conditions and nutrient status in the Elefsis Bay. Rapp. Comm. int. Explor. Mer Médit. 31:40.

Stergiou, K.I. 1986a. Production of cephalopods in Greek waters, 1928-1981. FAO Fish. Rep. 361:119-123.

Stergiou, K.I. 1986b. Pre-war changes in the abundance of *Pagellus erythrinus*, *Merluccius merluccius* and *Engraulis encrasicholus* in Greek waters and climatic change. FAO Fish. Rep. 361:99-105.

Stergiou, K.I. 1986c. Crustacean fishery in Greek waters. 1928-1981. Rapp. Comm. int. Mer Médit. 30: 13.

Stergiou, K.I. 1986d. On the assessment of the pelagic fishery resources in Greek waters. Rapp. Comm. int. Mer Médit. 30:241.

Stergiou, K.I. 1986e. On the anchovy and pilchard fishery in Greek waters, 1964-1982. Rapp. Comm. int. Mer Médit. 30:241.

Stergiou, K.I. 1986f. Fisheries catch statistics in the Patraikos, Korinthakos Gulfs and the Ionian Sea, 1964-1981. Greek Fish. News 65:62-64.

Stergiou, K.I. and D. Zouroudis. 1986. Pre-war fluctuations in the fisheries of scorpionfish, red mullet and striped mullet in Greek waters. Rapp. Comm. int. Mer Médit. 30:242.

Stergiou, K.I. 1987. Cephalopod abundance in Greek waters in relation to environmental fluctuations. Biologia Gallo-Hellenica 13: 25-34.

Stergiou, K.I. and T. Panou. 1987. Assessment and management of fishery resources in Greek waters: the Gadiformes. Greek Fish. News 77:73-78.

Stergiou, K.I. and L.I. Stergiou. 1987. Eels in Greek waters: production, export and cultural potentialities. Greek Fish. News 77:62-69.

Stergiou, K.I. 1988a. Spectral analysis of sardine fishery in Greek waters, 1964-1982. Rapp. Comm. int. Mer Médit. 31:282.

Stergiou, K.I. 1988b. Allocation, assessment and management of the cephalopod resources in Greek waters, 1964-1985. Rapp. Comm. int. Mer Médit. 31:253.

Stergiou, K. I. and N. Christou. 1988. The coastal fishery of caphalopods in Greek waters. Greek Fish. News 82:62-68.

Stergiou, K.I. and T. Panou. 1988. Allocation of gadoid resources in Greek waters, 1964-1985. Rapp. Comm. int. Mer Médit. 31:281.

Stergiou, K.I., C. Papaconstantinou and G. Petrakis. 1989. Fishery production in the Patraikos, Korinthiakos Gulfs and the Ionian Sea, 1980-1985. Proc. 2nd Hell. Symp. Ocean. Fish. 2 (in Greek).

Stergiou, K.I. Assessment and management of the cephalopod trawl fisheries resources in Greek waters. Environm. Toxic. Chem. (in press, a).

Stergiou, K.I. Multivariate analysis of the fishery of the northwestern coast of Greece, 1964-1981. Acta Adriat. 29 (in press, b).

Stergiou, K.I. Modelling and forecasting the fishery of pilchard. *Sardina pilchardus* in Greek waters using ARIMA time series models. J. Cons. CIEM (in press, c).

Stergiou, K.I. Multivariate analysis and management of cephalopods in Greek waters, 1964-1985. (in press, d).

Stergiou, K.I. and T. Panou. Ordination analysis and allocation of gadoids (*Merluccius merluccius* and *Micromesistius poutassou*) in Greek waters, 1964-1985. Thalassographica (in press).

Contributions to Fishbyte

Contributions to Fishbyte in the form of short papers, notes, letters to the editor and news items are constantly needed. Six pages of Fishbyte, including figures and references, is an absolute maximum for papers and shorter notes are preferred. Topics on which we focus are methods for fish stock assessment, parameter estimation and data acquisition and systems for the management of fishery resources, including economic, social, political and practical aspects. Contributions should preferably be in English but short contributions in Spanish or French will also be accepted. Figures do not need to be camera-ready, i.e., will be redrafted at ICLARM if necessary.

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