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Correlation analysis of interannual variation in cephalopod landings from European waters

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Abstract

The correspondence of interannual trends in cephalopod catches across European waters is analyzed. Data on cephalopod landings and, where available, fishing effort, by European countries were compiled and entered into a correlation analysis.

Relevant fishing effort data could be obtained only for the UK and Portugal. In the UK data, CPUE was strongly correlated with landings, suggesting that landings could be used as an index of abundance. For both Scotland and Portugal there was reasonable correspondence between interannual trends in catches by different fishing gears. However, it cannot be assumed that landings are always a realistic index of abundance.

In the Northeast Atlantic and the Mediterranean, interannual trends in landings of certain cephalopod categories in adjacent countries tended to be similar both across species and across areas. There was some evidence of corresponding trends over longer time periods and on a larger spatial scale, particularly for *Loligo forbesi*, pointing to the possible role of large-scale climatic or oceanographic factors in determining cephalopod abundance.

Introduction

Cephalopods are an increasingly important fishery resource in European waters and a number of species of squid, cuttlefish and octopus are landed commercially. Recent research has focused mainly on squid. In European waters, the squid species of greatest importance to commercial fisheries are the so-called common squids (Cephalopoda: Loliginidae), *Loligo forbesi* (veined squid) and *L. vulgaris* (European squid). Both are widely distributed in Northeast Atlantic and Mediterranean waters, although *L. forbesi* has a more northerly distribution and is scarce in southern Portuguese and Mediterranean waters, while *L. vulgaris* has a more southerly distribution and is rarely found in Scottish waters. An isolated, genetically distinct, population of *L. forbesi* is found in the Azores (Martins 1982, Brierley *et al.*, 1993, 1995; Pierce *et al.*, 1994a) while a sub-species of *L. vulgaris*, *L.v. reynaudii*, occurs on the southern and western coasts of Africa.

Landings of common squids (*Loligo* spp.) in European countries vary widely from year to year, apparently unrelated to fishing effort in those countries which record fishing effort (Pierce *et al.*, 1994b). Since

1990, annual landings in several European countries have decreased. However, this apparent trend has not been subject to rigorous analysis and previous data suggest that there may be cyclic variation in abundance (Pierce *et al.*, 1994b). The short (annual) life-cycle (Coelho *et al.*, 1994; Guerra & Rocha, 1994; Moreno *et al.*, 1994; Pierce *et al.*, 1994c; Porteiro & Martins, 1994; Collins *et al.*, 1995) may in part account for the high variability in abundance, since the populations are not buffered against fluctuations in recruitment or excessive mortality of breeding adults (Pierce & Guerra, 1994).

It is commonly thought that cephalopods such as *Loligo* spp. may be highly sensitive to variation in hydrographic conditions (Caddy, 1983; Forsythe, 1993). Indirect evidence that this is the case may be obtained if common trends in abundance are apparent across a wide geographical area.

The present paper examines correlations between interannual trends in squid and other cephalopod landings in different EC countries.

Materials and Methods

ICES supplied data on squid landings 1973-94 by European countries fishing in the Northeast Atlantic and data on total annual cephalopod landings in EC countries 1965-92 from the Northeast Atlantic (FAO area 27) and Mediterranean (FAO area 37) were assembled from FAO Yearbooks of Fishery Statistics, Catches and Landings (Food & Agriculture Organization, Rome). Long-finned (loliginid) squid landings from the NE Atlantic were also compiled by direct access to national databases in England and Wales (1980-94), Scotland (1904-94), France (1960-94), Spain (1983-94), Portugal (1960-93) and the Azores (1948-93). Where possible the data were subdivided by area and/or gear. Where effort data were available, overall CPUE was derived (total landings divided by total effort).

Similarities in inter-annual trends for different data categories were evaluated by non-parametric correlation analysis (BMDP statistical software). Due to the very large number of possible comparisons, the analysis is restricted to answering specific questions. The first three questions relate to the utility of landings data as an abundance index:

(a) Are the same trends seen in landings and CPUE?
(b) Are the same trends seen for different gear types?
(c) Are the same trends seen in catches by different countries fishing in the same area?
Two further questions relate to the trends over large areas:
(d) Are the same trends seen for different cephalopod categories within the same area?
(e) Are the same trends seen for a particular species in different areas?

Comments on the categorization of cephalopod landings in published data

Cephalopods are classified into a series of categories by FAO, the use of which has been inconsistent, and not all of which are mutually exclusive. Some cephalopod landings are recorded as "Cephalopods not elsewhere identified". Many EC countries recorded squid landings from area 27 as "Squid (Loliginidae or Ommastrephidae)" up to approx. 1980, after which landings were categorized as "*Loligo* spp.". For Scotland, Northern Ireland, Ireland and Portugal it is reasonable to assume that, prior to 1980, the squid landed was usually *Loligo*. The category "Squid (Loliginidae or Ommastrephidae)" continues to appear until 1985 in data for England & Wales, possibly reflecting participation in the *Todarodes sagittatus* fishery in the early 1980s. France recorded squid landings as "*Loligo* spp." until 1980 and as "Squid (Loliginidae or Ommastrephidae)" thereafter. However, landings are probably still mainly of *Loligo forbesi* and/or *L. vulgaris*. Spain has switched from always recording "*Loligo* spp.", "*Illex illecebrosus*" and "*Todarodes sagittatus*" separately to recording an increasing proportion of landings as "Squid (Loliginidae or Ommastrephidae)". Because Spain has a fishery for ommastrephids, this category is certain to include a mixture of species, including the ommastrephid *Todaropsis eblanae* as well as the above mentioned species. Similar problems of categorization arise less frequently for cuttlefish and octopus, but Spain and Portugal have both switched between using "Sepiidae or Sepiolidae" and "*Sepia officinalis*" for all cuttlefish landings. Also, Spain normally records octopus landings as "Octopodidae" but during 1973-6 recorded all octopus landed as "*Eledone*". France recorded landings of "*Octopus vulgaris*" in 1975-76 but normally recorded "Octopodidae". Note that the *Illex* species landed by Spain is more likely to be *Illex coindetii* than *I. illecebrosus*, since the latter is a Northwest Atlantic species.

Data for FAO area 37 (Mediterranean) present fewer problems, but France and Greece both switched (in 1981) from recording "Sepiidae or Sepiolidae" to recording "*Sepia officinalis*". Spain and Greece recorded

landings of *Illex coindetii*, although Greece switched in 1981 to recording "Squid (Loliginidae or Ommastrephidae)". Greece also started recording *Octopus vulgaris* in 1983, as well as Octopodidae.

Results

(a) Landings and CPUE for Loligo

This analysis used data extracted directly from National databases. In data on *Loligo* landings from Scotland (Fig. 1) and England + Wales, landings and CPUE were significantly correlated, for individual gear-types and overall (Table 1). For Portugal, annual *Loligo* landings from the trawl fishery (1988-1992) were negatively correlated with CPUE but the trend is not statistically significant. Data for other countries were not available.

(b) Comparisons between gears for Loligo landings and CPUE

This analysis used data extracted directly from National databases. Landings of *Loligo* in Scotland by different gear categories were correlated, except for seine nets versus heavy trawling gear and the same was true of CPUE (Fig. 2, Table 2). Landings of *Loligo* in England by different gears were generally not correlated, except for heavy trawls versus seine, and this also applies for CPUE data. Landings of loliginids in Portugal from the artisanal fishery were correlated with trawl and with seine landings.

(c) Comparisons between landings of Loligo by different countries fishing in the same area

This analysis used data provided by ICES. The statistical power of the analysis is restricted by incomplete data. Possibly many missing values actually represent zero catches but it was necessary to assume they were missing data. Interrannual trends in landings of *Loligo* by different countries fishing in the same ICES fishery subdivision were well correlated in some important squid fishery areas, particularly the west coast of Scotland (VIa; Fig. 3) and the Irish Sea areas (VIIa) but not in other areas (Table 3). In the case of area VIa, it is possible that landings by Ireland are poorly correlated with those of other countries because landings from VIb were included with those from VIa.

(d) Different cephalopod species within the same area

This analysis used data published by FAO. For all countries except Spain, the different FAO categories of squid, cuttlefish and octopus in area 27 were combined for analysis, but the squid can be assumed to have been mostly *Loligo* spp.

For area 27 as a whole, there were no significant correlations between landings of the three main taxa, but positive correlations were seen in landings by Spain, except for *Todarodes* (Fig. 4), and France, also between squid and cuttlefish for England and Wales (Table 4).

More categories of cephalopods are distinguished in Mediterranean (area 37). Overall, there were positive correlations between many of these categories (Table 5). For individual countries (Italy, Greece, Malta and Cyprus), some positive correlations between species were seen, although *Illex* landings in Greece were negatively correlated with those of other species, while *Sepia* and *Todarodes* landings in Italy were negatively correlated (Fig. 5). Squid and octopus landings in Spain were also negatively correlated.

(e) Trends across large areas

ICES data were available for many countries: the two examples chosen here are for countries fishing across different, but overlapping, areas. ICES landings data for England & Wales showed comparable interannual trends in *Loligo* landings for many fishery areas, with only landings from the northern North Sea (IVa) being negatively correlated with landings from elsewhere (Table 6). Spain fishes squid from a wider area, and positive correlations are seen between landings in Spain from the west coasts of Scotland (VI) and Ireland (VIIbc), the Celtic Sea (VIIg-k), the Bay of Biscay (VIII) and west Portugal (IX) (Fig. 6, Table 6).

The FAO data show some correspondence between landings of *Loligo* from area 27 by different European countries, and this was also the case for cuttlefish (Table 7). In area 37, landings of these cephalopod categories by different countries were as often negatively correlated as positively correlated (Table 8), although landings of octopods by different countries were mostly positively correlated. A difficulty with interpreting these trends is that the fishing areas of different countries overlap extensively.

Comparisons between landings from FAO areas 27 and 37 are possible using area totals and for the two countries, France and Spain, which routinely fish for cephalopods in both areas. Squid landings from the two areas tended to be positively correlated, octopus landings negatively correlated. Overall cuttlefish landings from the two areas were correlated but landings of cuttlefish in France from the two areas were negatively related (Table 9).

Longer time series of data for long-finned squid (*Loligo*) landings were obtained directly from National databases held in the Azores, Portugal and Scotland. Additional data series were obtained for France and Spain but covered shorter periods. Previous comments about the FAO data notwithstanding, it appeared from the new Spanish data (1983-94) that published (area 27) totals for FAO categories "*Loligo*" and "Squid (Loliginidae or Ommastrephidae)" should be added to approximate to total loliginid landings. These new FAO totals were used for pre-1983 data and combined with the new 1983-94 data to create a new data series. The new French data (1980-94) were similarly grafted onto earlier FAO data to create a new data series. Landings by Scotland were correlated with those in France and the Azores, while landings in Spain were negatively correlated with those in the Azores (Table 10). The pattern of landings since 1980 appears strikingly similar for Scotland, the Azores, Portugal and France (Fig. 7). However, statistically, only the correlation between Scotland and the Azores is significant over this period (Table 10).

Discussion

This kind of analysis will always be limited by the quality of the data available, but collection and reporting of data on cephalopods, which are not quota species in EC waters, is particularly poor (Anon., 1993, 1994; Donoso-Perez & Forest, 1993; Pierce & Guerra, 1994). The main problems are:

(a) Limited objectives of data collection by National Governments. Many countries record total cephalopod landings but not all record associated data on location or fishing effort.

(b) Low accuracy: there is ample scope for human error in the way data are collected. In the UK fishery we are aware of examples of large amounts of squid going unrecorded due to categorization as "other species" or being landed by small boats, also of quota species being mis-reported as squid.

(c) Inconsistent categorization of cephalopods: continuity of data over time is compromised by splitting and lumping of categories (see above).

(d) Incomplete reporting to International bodies.

Additionally, interpreting trends in such data series is difficult. When a large number of variables is being analysed, correlation analysis will inevitably generate some spurious correlations, and correlations may not indicate any underlying causal relationship. Temporal autocorrelation may also be a problem, although for short-lived species with non-overlapping generations, abundances in two adjacent years may probably be regarded as independent, because the only direct link is through recruitment. In any case, the approach used in the present paper represents one of the few feasible means of addressing the questions raised.

Pierce *et al.* (1994b) argued that, in the Scottish fishery, landings of *Loligo* were a reasonable index of abundance because they were strongly correlated with CPUE. Even though squid may be targetted by Scottish fishermen in years of high abundance, the impact of this on overall CPUE (by the entire fleet) appears to have been negligible. This conclusion is supported by the present analysis for Scottish and English data but not for Portuguese data. Thus, for countries which report landings but not effort there must remain doubt as to whether landings are related to abundance.

The UK data also show that landings and CPUE recorded for different gear-types do not always record the same picture. Similarly, trends in landings by different countries fishing in the same ICES fishery subdivision did not always correspond. This is likely to reflect differences in fishing effort or methods rather than abundance, so it is generally preferable to treat data from different countries separately.

Analyses of both FAO and ICES datasets showed the existence of parallel trends both across species and across areas: there are certainly more significant positive correlations than would have been expected by chance alone. At present however we can only provisionally suggest that this might, to some extent, reflect a common response to changing environmental conditions.

The analysis of data obtained by direct access to National databases was particularly interesting, revealing striking correspondence between trends in landings of *Loligo* in Scotland and the Azores over the last 15 years. Landings in France and Portugal showed somewhat similar trends, while the pattern of Spanish landings was entirely different. It may be relevant that Scotland and the Azores are unique in landing only *Loligo forbesi*, albeit possibly different subspecies, whereas the other countries land a mixture of *Loligo forbesi* and *L. vulgaris*. If this correspondence between trends in midAtlantic and Continental shelf landings can be shown to reflect trends in abundance rather than a common response of fisheries to changing technology and

market forces - and in the case of Scotland we believe it can - this represents the best evidence yet available that squid abundance could be controlled by large-scale climatic or oceanographic factors. In a complementary analysis, Pierce (1995) showed that squid landings in Scotland could be well-predicted from sea surface temperature data.

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Table 1

Correlations between *Loligo* landings and CPUE

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. Data for individual gear-types are from 1980-94 (i.e. N=15). The all-gear data for Scotland goes back to 1974 (N=21).

Gear	Scotland	England
Heavy trawl	**0.946**	**0.957**
Light trawl	**0.986**	**0.950**
Pair trawl	**0.986**	**0.975**
Seine	**0.954**	**0.807**
All	**0.979**	**0.589**

Table 2

Correlations between gear-types for *Loligo* landings and CPUE.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. Data for individual gear-types are from 1980-94 (N=15) in Scotland and England + Wales, and 1986-93 (N=8) in Portugal. Heavy = heavy otter trawl, Light = light otter trawl, Pair = pair trawl, Seine = demersal seines, Art. = artisanal fishery.

Landings, Scotland

Gear	Heavy	Light	Pair	Seine
Light	**0.557**			
Pair	0.511	**0.864**		
Seine	0.050	**0.664**	**0.711**	
All	**0.664**	**0.982**	**0.857**	**0.632**

CPUE, Scotland

Gear	Heavy	Light	Pair	Seine
Light	**0.696**			
Pair	**0.579**	**0.782**		
Seine	0.025	**0.564**	**0.611**	
All	**0.725**	**0.989**	**0.775**	**0.557**

Landings, England & Wales

Gear	Heavy	Light	Pair	Seine
Light	-0.186			
Pair	-0.393	-0.036		
Seine	**0.554**	0.014	0.150	
All	-0.486	0.271	**0.700**	0.079

CPUE, England & Wales

Gear	Heavy	Light	Pair	Seine
Light	-0.196			
Pair	-0.325	0.139		
Seine	**0.679**	0.104	-0.264	
All	-0.214	0.032	**0.896**	-0.225

Landings, Portugal

Gear	Trawl	Art.	Seine.
Art.	**0.810**		
Seine	0.527	**0.898**	
All	**0.952**	**0.857**	**0.647**

Table 3

Correlations between landings of squid* by different countries fishing in the same area.

Significant correlations are indicated by bold type. The anlysis is based on ICES data (1973-94). *Landings of "*Loligo*" and "Squid not elsewhere included" were summed because the use of these categories was ambiguous. For most countries, the squid can be assumed to be *Loligo*. Scot = Scotland, N. Ire = Northern Ireland, I. Man = Isle of Man, Engl = England & Wales, Belg = Belgium, , Fran = France, Port = Portugal, IVa = Northern North Sea, IVb = central North Sea, IVc = Southern North Sea, VIa = west of Scotland, VIb = Rockall, VIIa = Irish Sea, VIIbc = West of Ireland, VIId = Eastern English Channel, VIIe = Western English Channel, VIIf = Bristol Channel, VIIg-k = Celtic Sea, VIII = Bay of Biscay, IX = West Portugal.

IVa (N=9a, 14b, 15c)

	Engl	Fran
Fran	0.210[a]	
Scot	0.018[b]	-0.258[c]

IVb (N=17[a], 20[b])

	Belg	Engl
Engl	0.397[c]	
Scot	0.279[d]	**0.509**[b]

IVc (N=13[a], 15[b], 7[c])

	Belg	Engl
Engl	0.136[a]	
Fran	0.275[b]	0.638[c]

VIa (N=13[a], 16[b], 19[c], 10[d], 11[e], 14[f], 17[g], 8[h], 12[i])

	Engl	Fran	Ireland	Scot
Fran	**0.495**[a]			
Ireland	-0.242[b]	-0.219[c]		
Scot	**0.409**[d]	0.253[e]	0.027[g]	
Spain	**0.571**[d]	**0.618**[f]	-0.214[h]	-0.007[i]

VIb (N=5[a], 12[b], 7[c], 4[d])

	Engl	Fran	Scot
Fran	0.205[a]		
Scot	0.060[b]	0.300[c]	
Spain	0.071[a]	-0.316[d]	-0.400[b]

VIIa (N=19[a], 11[b], 12[c], 16[d], 14[e], 18[f], 21[g], 8[h])

	Belg	Engl	Fran	I. Man	Ireland	N. Ire
Engl	0.215[a]					
Franc	0.132[b]	**0.557**[c]				
I. Man	0.046[c]	**0.817**[d]	0.169[b]			
Ireland	0.235[d]	0.255[f]	0.357[c]	0.000[g]		
N. Ire	-0.119[e]	**0.652**[g]	0.455[c]	**0.812**[e]	0.185[f]	
Scot	0.020[d]	**0.738**[f]	0.347[b]	**0.697**[e]	-0.261[d]	0.382[f]

VIIbc (N=5[a], 9[b], 14[c])

	Engl	Fran	Ireland
Fran	-0.158[a]		
Ireland	0.418[b]	0.359[b]	
Spain	0.892[a]	0.170[c]	-0.299[b]

VIId (N=21[a], 16[b])

	Belg	Engl
Engl	0.055[a]	
Fran	0.010[b]	**0.590**[b]

VIIe (N=19[a], 13[b])

	Belg	Engl
Engl	0.115[a]	
Fran	0.232[b]	**0.658**[b]

VIIf (N=18[a], 15[b], 13[c])

	Belg	Engl
Engl	-0.127[a]	
Fran	-0.203[b]	**0.577**[c]

VIIg k (N=21[a], 14[b], 17[c], 16[d], 12[e])

	Belg	Engl	Franc	Ireland
Engl	-0.047[a]			
Fran	**0.459**[b]	0.205[a]		
Ireland	-0.088[c]	**0.759**[c]	0.239[c]	
Spain	-0.188[d]	-0.196[d]	-0.031[b]	-0.358[e]

VIII (N=8[a], 3[b], 5[c], 15[d]) + IX (N=14)*

	Belg	Engl	Fran	Port*
Engl	-0.048[a]			
Fran	0.500[b]	-0.200[c]		
Spain	-0.500[b]	0.500[c]	-0.220[d]	
Spain*				0.117

Table 4

Correlations between landings of different cephalopod categories: FAO area 27.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. The analysis is based on FAO data for landings from area 27, 1965-1992. Only countries recording more than one category* of cephalopod are included. *Categories have been combined where appropriate (see text). Cuttle = "*Sepia officinalis*" + "Sepiidae or Sepiolidae", Oct = "*Octopodidae*" or "*Octopus vulgaris*" or "*Eledone* spp.", Squid = "*Loligo* spp." or "Squid (Loliginidae or Ommastrephidae)" or "*Illex illecebrosus*" or "*Todarodes sagittatus*", *Tod.* = "*Todarodes sagittatus*".

England & Wales (N=10)

	Squid	Cuttle
Cuttle	**0.675**	
Oct	0.119	-0.480

Channel Islands (N=9)

	Squid
Cuttle	0.098

Ireland (N=6)

	Squid
Cuttle	0.530

France (N=19[a], 15[b])

	Squid	Cuttle
Cuttle	**0.691**[a]	
Oct	**0.644**[b]	**0.716**[b]

Spain (N=20[a], 8[b], 27[c], 28[d], 19[e])

	Loligo	*Illex*	*Tod.*	Squid	Cuttle
Illex	**0.447**[a]				
Tod.	0.108[b]	-			
Squid	-	-	-		
Cuttle	**0.725**[c]	**0.520**[c]	0.542[b]	**0.701**[c]	
Oct	**0.413**[d]	**0.505**[a]	0.084[b]	**0.662**[d]	**0.766**[e]

Area 27 totals (N=28)

	Squid	Cuttle
Cuttle	0.136	
Oct	0.281	-0.149

Table 5

Correlations between landings of different cephalopod categories: FAO area 37.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. The analysis is based on FAO data for landings from area 37, 1965-1992. Only countries recording more than one category* of cephalopod are included. *Categories have been combined where appropriate (see text). Cuttle = "*Sepia officinalis*" + "Sepiidae or Sepiolidae", Oct = "*Octopodidae*" or "*Octopus vulgaris*" or "*Eledone* spp. Squid = "*Loligo* spp." or "Squid (Loliginidae or Ommastrephidae)" or "*Illex coindetii*" or "*Todarodes sagittatus*", *Tod.* = "*Todarodes sagittatus*", *O.vul* = "*Octopus vulgaris*", *Eled.* = *Eledone* spp.

Spain (N=20[a], 11[b], 28[c])

	Lol.	*Illex*	Squid	Cuttle
Illex	0.477[b]		-	
Squid	-			
Cuttle	-0.012[a]		0.058[a]	
Oct	**-0.701**[c]	-0.037[b]	**-0.740**[c]	**-0.381**[a]

France (N=19)

	Lol.	Cuttle
Cuttle	0.388	
O. vul	-0.060	0.037

Italy (N=28)

	Lol.	*Tod.*	*Sepia*	*O. vul*
Tod.	0.260			
Sepia	0.086	**-0.439**		
O. vul	**0.457**	**0.796**	-0.232	
Eled.	**0.334**	**0.397**	-0.199	**0.536**

Malta (N=28)

	Lol.	Cuttle
Cuttle	**0.753**	
Oct	**0.769**	**0.672**

Greece (N=20[a], 8[b], 10[c])

	Lol.	*Illex*	Squid	Cuttle	*O. vul*
Illex	-0.696[b]				
Squid	-	-			
Cuttle	**0.877**[a]	**-0.823**[b]	**0.823**[a]		
O. vul	**0.891**[c]	-	**0.891**[c]	**0.952**[c]	
Oct.	**0.791**[a]	-0.609[b]	**0.829**[a]	**0.845**[a]	**0.709**[c]

Cyprus (N=20)

	Cuttle
Oct.	**0.869**

Area 37 totals (N=28 or N=15[a])

	Lol.	*Tod.*	*Illex*	Squid	*O. vul*	*Eled.*	Cuttle
Tod.	0.204						
Illex	-0.338[a]	0.205[a]					
Squid	**0.772**	**0.705**	-0.010[a]				
O. vul	0.199	**0.827**	-0.007[a]	0.593			
Eled.	-0.027	**0.338**	0.171[a]	0.196	**0.458**		
Cuttle	**0.550**	**0.581**	-0.096[a]	**0.694**	**0.744**	0.287	
Oct	0.127	**0.878**	0.254[a]	**0.594**	**0.894**	**0.546**	**0.639**

Table 6

Correlations between landings from different ICES areas.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. Codes for ICES Fisheries Subdivisions: IVa = Northern North Sea, IVb = central North Sea, IVc = Southern North Sea, VIa = west of Scotland, VIb = Rockall, VIIa = Irish Sea, VIIbc = West of Ireland, VIId = Eastern English Channel, VIIe = Western English Channel, VIIf = Bristol Channel, VIIg k = Celtic Sea, VIII = Bay of Biscay, IX = West Portugal.

Top right: Spain (N=5[a], 12[b], 8[c], 15[d])

	IVa	IVb	IVc	VIa	VIb	VIIa	VIIbc	VIId	VIIe	VIIf	VIIg-k	VIII	IX
IVa													
IVb	-0.257[a]												
IVc	0.350[b]	**0.596**[a]									**0.590**[b]	**0.526**[b]	**0.756**[b]
VIa	0.260[f]	0.049[e]	0.460[f]		0.700[b]		0.284[b]				0.228[c]	0.476[c]	0.000[c]
VIb	0.242[a]	-0.109[f]	0.264[g]	0.057[f]			0.024[c]						
VIIa	-0.362[c]	0.167[g]	0.469[a]	**0.449**[m]	0.216[f]						**0.846**[d]	-0.323[d]	**0.492**[d]
VIIbc	-0.567[d]	0.147[h]	0.009[g]	0.368[h]	-0.538[g]	0.028[h]							
VIId	-0.437[e]	**0.448**[g]	0.248[a]	0.387[m]	0.177[f]	**0.557**[e]	0.390[b]						
VIIe	-0.316[c]	0.319[e]	**0.723**[a]	**0.617**[m]	0.116[f]	**0.708**[m]	0.349[b]	**0.559**[m]					
VIIf	0.009[e]	0.043[e]	0.340[g]	**0.526**[a]	0.161[f]	**0.541**[m]	0.396[b]	**0.481**[m]	**0.598**[k]				
VIIg k	**-0.496**[c]	**0.615**[a]	**0.764**[a]	0.048[m]	-0.172[f]	**0.460**[e]	**0.681**[b]	0.227[e]	**0.532**[k]	0.290[m]		-0.121[d]	**0.551**[d]
VIII	-0.691[d]	-0.097[h]	-0.639[d]	0.280[h]	-0.207[h]	0.225[h]	0.185[h]	**0.620**[b]	0.346[h]	0.122[h]	0.274[h]		0.333[d]
IX													

Bottom left: England & Wales (N=13[a],11[b], 14[c], 8[d], 18[e], 16[f], 20[g], 10[h], 12[i], 11[j], 9[k], 15[l], 19[m], 17[n], 21[o])

Table 7

Correlations between landings by different countries: FAO area 27.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. The analysis is based on FAO data for landings from area 27, 1965-1992. Scot = Scotland, N. Ire = Northern Ireland, Irel = Ireland, I. Man = Isle of Man, Engl = England & Wales, Belg = Belgium, Ch Isl = Channel Islands, Fran = France, Port = Portugal, Germ = Germany, Norw = Norway, Icel = Iceland, Denm = Denmark, Holl = Holland. The first tabulation, for "*Loligo* spp." also includes "Squid (Loliginidae or Ommastrephidae)" for those countries which either normally land only *Loligo* or record other Ommastrephids separately (see text).

"Loligo spp." [or "Squid (Loliginidae or Ommastrephidae)"] (N=26[a], 17[b], 12[c], 28[d], 20[e], 27[f], 15[g], 10[h], 18[i], 25[j], 19[k])

	Scot	N. Ire	Irel	I. Man	Engl	Belg	Ch Isl	Fran	Spain
N. Ire	0.266[a]								
Irel	**0.440**[b]	0.016[g]							
I. Man	0.438[c]	**0.857**[h]	0.219[c]						
Engl	**0.577**[d]	**0.767**[a]	0.268[b]	**0.565**[c]					
Belg	**0.331**[d]	0.237[a]	**0.453**[b]	-0.112[c]	**0.412**[d]				
Ch Isl	0.212[e]	-0.147[i]	0.025[b]	-0.275[c]	**0.394**[e]	**0.474**[e]			
Fran	**0.564**[d]	-0.066[a]	0.197[b]	0.287[c]	0.138[d]	**0.322**[d]	0.271[e]		
Spain	-0.191[d]	-0.475[a]	-0.379[b]	-0.397[c]	**-0.540**[d]	-0.232[d]	**-0.430**[e]	0.019[d]	
Port	0.099[f]	0.114[j]	0.109[b]	0.298[c]	0.208[f]	0.066[f]	**0.537**[k]	-0.132[f]	-0.255[f]

Illex (N=6[a], 8[b])

	Spain	Port
Port	0.406[a]	
Germ	**-0.796**[b]	0.000[b]

Todarodes (N=7[a], 4[b])

	Spain	Norw
Norw	-0.357[a]	
Icel	-0.400[b]	0.526[a]

Cuttlefish (N=10[a], 9[b], 17[c], 25[d], 12[e], 11[f], 8[g], 18[h], 19[i], 26[j])

	Denm	Holl	Engl	Ch Isl	Fran	Spain
Holl	0.138[a]					
Engl	**0.829**[b]	-				
Ch Isl	**0.854**[b]	-	**0.748**[b]			
Fran	0.303[c]	**0.661**[b]	**0.842**[a]	**0.891**[b]		
Spain	**-0.722**[d]	-0.133[e]	**0.728**[b]	0.466[g]	0.221[h]	
Port	0.287[d]	-0.336[f]	0.127[e]	0.241[h]	**0.558**[i]	-0.303[j]

Octopodidae (N=5[a], 6[b], 10[c], 15[d], 27[e])

	Irel	Engl	Fran	Spain
Engl	-0.216[a]			
Fran	-0.746[b]	0.549[c]		
Spain	-0.795[b]	0.085[c]	0.335[d]	
Port	-0.500[b]	**0.596**[c]	**0.601**[d]	-0.390[e]

Table 8

Correlations between landings by different countries: FAO area 37.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. The analysis is based on FAO data for landings from area 27, 1965-1992. Fran = France, Gree = Greece, Ital = Italy, Cypr = Cyprus, *Ts* = *Todarodes sagittatus*, *Ov* = *Octopus vulgaris*, *El* = *Eledone* spp..

"Loligo spp." (N=28[a], 20[b])

	Fran	Spain	Italy	Gree
Spain	**-0.326**[a]			
Italy	**-0.320**[a]	-0.147[a]		
Gree	-0.257[b]	-0.234[b]	0.010[b]	
Malta	**0.347**[a]	-0.322[a]	0.147[a]	**-0.485**[c]

Illex (N=4[a], 11[b], 8[c])

	Spain	Gree
Gree	-0.600[a]	
Ts Ital	-0.205[b]	**-0.749**[c]

Cuttlefish (N=19[a], 20[b], 28[c])

	Fran	Spain	Italy	Gree	Malta
Spain	-0.137[a]				
Italy	**0.535**[a]	-0.070[b]			
Greec	**-0.791**[a]	-0.035[b]	**-0.518**[c]		
Malta	**0.426**[a]	-0.166[b]	-0.153[c]	-0.241[b]	
Cypr	**-0.510**[a]	-0.030[b]	-0.296[b]	**0.702**[b]	-0.469[c]

Octopodidae (N=19[a], 28[b], 20[c])

	Fran	Spain	*Ov* Ital	*El* Ital	Gree	Malta
Spain	**-0.409**[a]					
Ov Ital	-0.053[a]	**0.675**[b]				
El Ital	-0.327[a]	**0.620**[b]	**0.536**[b]			
Gree	-0.230[a]	**0.724**[c]	**0.716**[c]	**0.588**[c]		
Malta	-0.118[a]	0.234[b]	0.114[b]	0.214[b]	**-0.789**[c]	
Cypr	-0.092[a]	**0.583**[c]	**0.501**[c]	**0.603**[c]	**0.787**[c]	**-0.573**[c]

Table 9.

Correlations between landings from FAO areas 27 and 37.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. Cuttle = cuttlefish, *Tod.* = *Todarodes sagittatus*. *Two species of *Illex* are recorded, but most *Illex* landings in both areas are likely to be of *I. coindetii*.

(N=28[a], 19[b], 15[c], 9[d], 24[e], 10[f], 23[g])

	Loligo	*Illex**	*Tod.*	Squid	Cuttle	Octopus
France	-	-	-	0.171[a]	**-0.538**[b]	-0.158[c]
Spain	**0.542**[a]	**0.675**[d]	-	**0.643**[a]	0.123[b]	**-0.461**[e]
TOTAL	0.069[a]	0.296[f]	**0.368**[g]	0.070[b]	**0.509**[a]	**-0.322**[a]

Table 10.

Correlations between landings of long-finned squid from the NE Atlantic by different European countries.

Spearman's rank correlation coefficients. Significant correlations are indicated by bold type. The analysis is based on data obtained by direct access to National databases, supplemented by FAO data on landings from area 27, 1948-1994 and 1980-1994.

Top right: 1980-1994 (N=15[a], 14[b])

	Scotland	France	Spain	Portugal	Azores
Scotland		0.379[a]	-0.400[a]	0.284[b]	**0.508**[b]
France	**0.439**[a]		**-0.579**[a]	-0.002[b]	0.279[b]
Spain	-0.216[a]	0.090[a]		0.103[b]	-0.248[b]
Portugal	0.060[b]	0.022[a]	0.186[a]		-0.231[b]
Azores	**0.270**[c]	-0.208[a]	**-0.750**[a]	-0.109[c]	

Bottom left: 1948-1994 (N=30[a], 34[b], 45[c], 29[d], 28[e], 33[f])

Figure 1

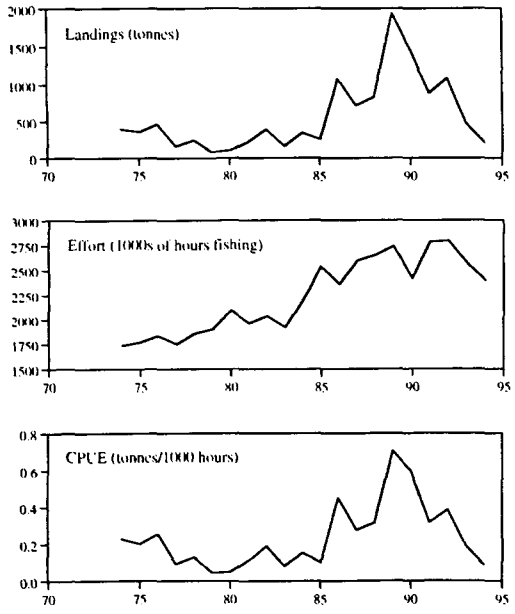
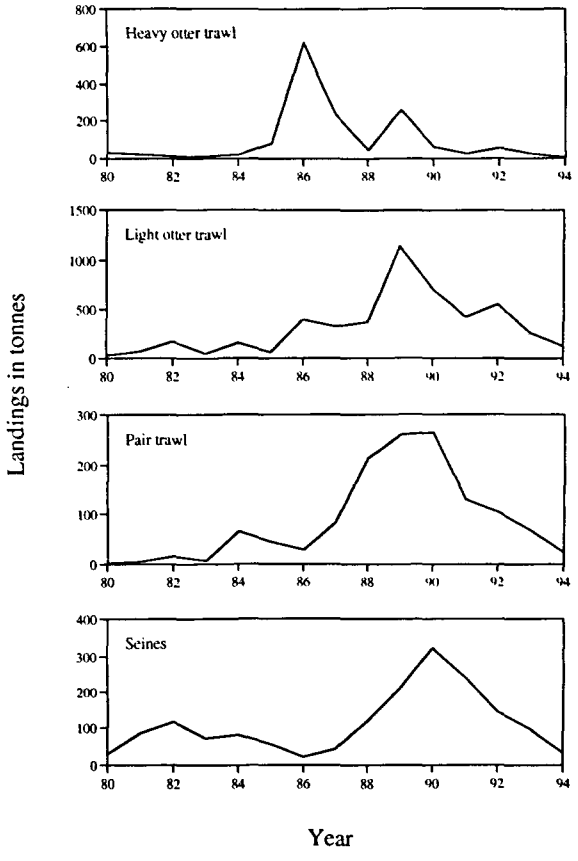


Figure 2



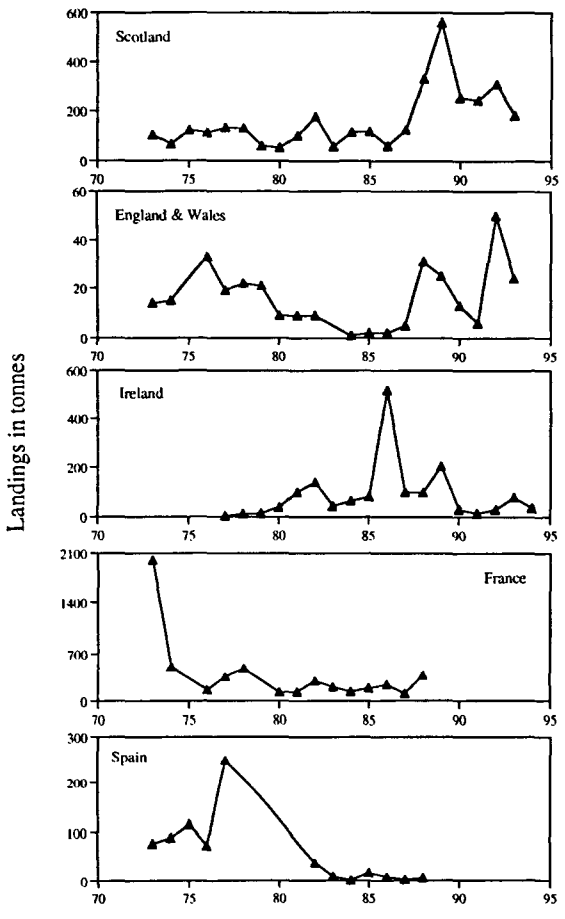


Figure 3

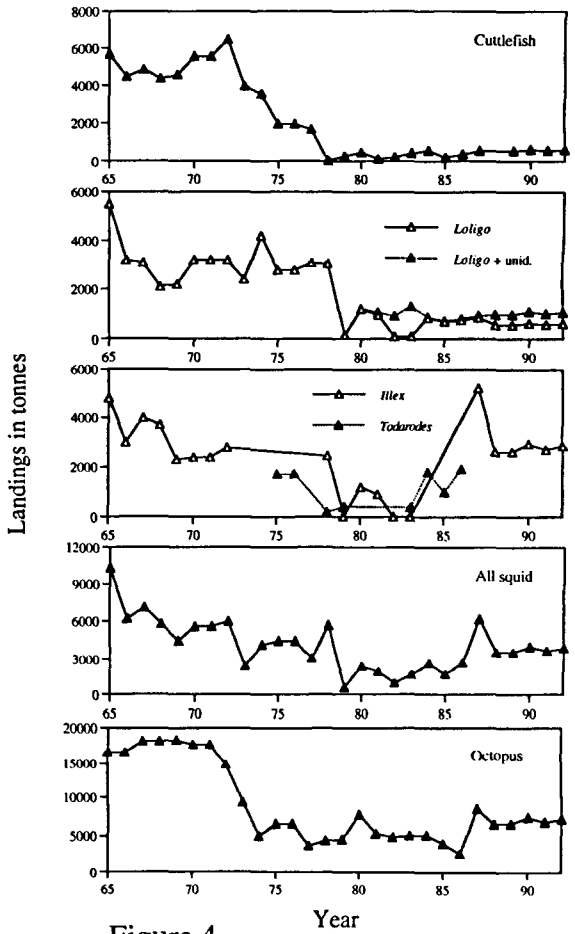


Figure 4

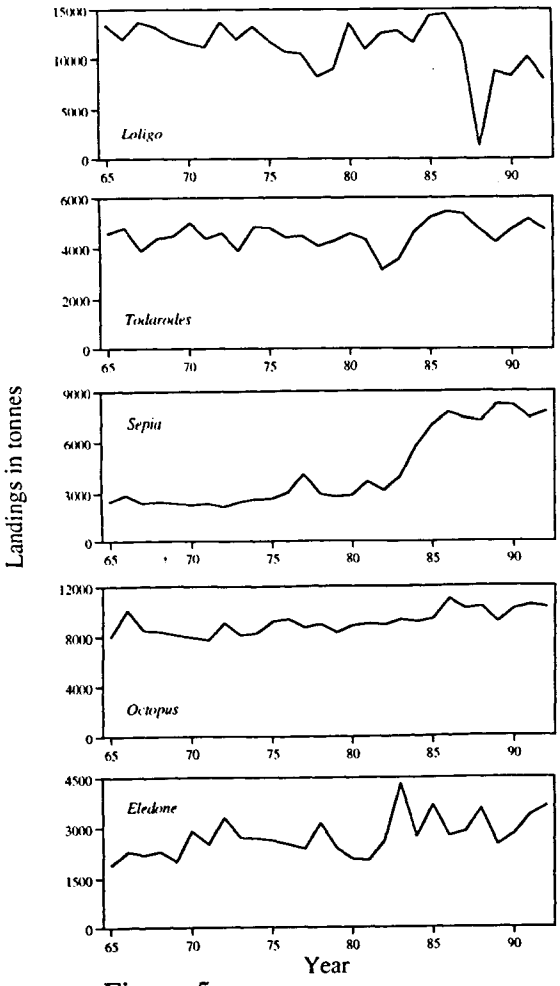


Figure 5

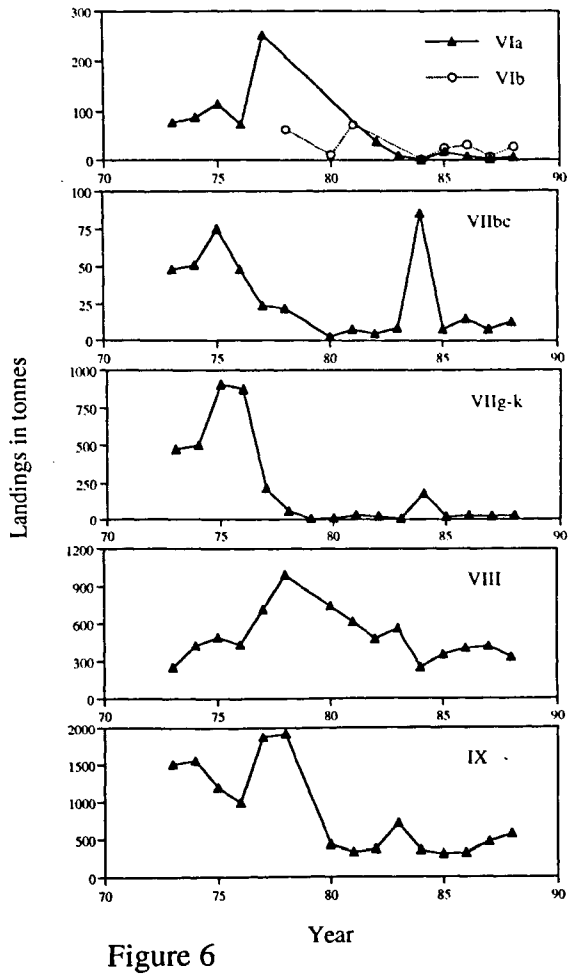


Figure 6

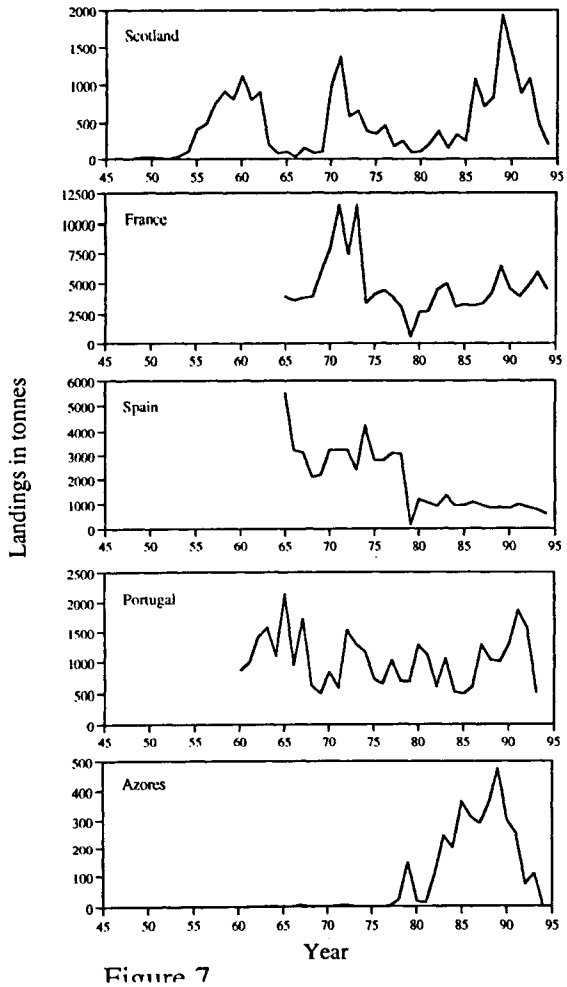


Figure 7

Figure legends

Figure 1. Landings of *Loligo* in Scotland, hours fishing and overall CPUE for *Loligo*, 1980-94.

Figure 2. Landings of *Loligo* in Scotland classified by gear-type, 1980-94.

Figure 3. Landings of squid (presumed to be *Loligo*) from ICES fishery subdivision VIa (west coast of Scotland) by different European countries, 1973-94.

Figure 4. Landings of different cephalopods from FAO area 27 (NE Atlantic) by Spain, 1965-92.

Figure 5. Landings of different cephalopods from FAO area 37 (Mediterranean) by Italy, 1965-92.

Figure 6. Landings of squid from different ICES fishery subdivisions by Spain, 1973-94. Note that, for several of these years, no data were reported to ICES.

Figure 7. Landings of long-finned squid (*Loligo*) from the NE Atlantic by Scotland, France, Spain, Portugal and the Azores, 1948-94. Only the first and last of these datasets extend back to 1948.