Influência da colaboração sobre o impacto das publicações em diferentes níveis deagregação: análise da investigação espanhola sobre Ciência Marinha

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Resumen — Este artículo presenta un análisis bibliométrico de la actividad científica española en área de Ciencias del Mar a través del análisis de sus publicaciones en el Science Citation Index durante el período 1994-2004. La evolución de la colaboración durante el período y la influencia de los diferentes tipos de colaboración en el impacto de la actividad científica han sido estudiadas. En total 6.898 artículos representan la producción científica española en el área. Se observa un incremento en el número de trabajos y en el impacto de las revistas de publicación durante el periodo de estudio. El número de artículos realizados en colaboración internacional se incrementa más rápidamente que aquellos realizados en colaboración nacional o sin colaboración, y tienden a estar publicados en mejores revistas y a recibir más citas. Los indicadores de "ganancia en factor de impacto" y "ganancia en citas" se utilizan para medir los efectos de diferentes tipos de colaboración en el impacto de la investigación de los principales sectores institucionales en el país, los principales centros de investigación y los científicos más productivos. En términos generales se observa un efecto positivo de la colaboración sobre el impacto de la investigación, pero a medida que el nivel de agregación de análisis se reduce este efecto positivo es menos claro. En el caso de los científicos más productivos (a nivel individual) esta buena relación entre colaboración internacional e impacto de las publicaciones no siempre se observa

Palabras clave: Análise bibliométrico; Ciencias del Mar; España; colaboración científica; actividad científica; factor de impacto ;

Influence of collaboration on the impact of publications at different levels ofaggregation: analysis of Spanish research on Marine Science

ABSTRACT –This paper presents a bibliometric analysis of the scientific activity of Spain in Marine Science through the analysis of itspublications in the Science Citation Index during the period 1994-2004. The evolution of collaboration over the period and the influence of different types of collaboration on the impact of research are studied. Spanish production accounts for 6,898 publications. An increment in the number of publications and in the impact of the publication journals over time is observed. Internationally-coauthored publications increase faster than those with national or with no collaboration at all and tend to be published in more prestigious journals and to receive a higher number of citations. The indicators “gain in impact factor” and “gain in citations” are used to measure the effects of different types of collaboration over the impact of the research for the main institutional sectors in the country, main research centres and most productive scientists. A positive effect of collaboration over the impact of research is observed, but as the aggregation level of analysis decreases this positive effect is less clear. In the case of individual scientists this good relationship between internationalcollaboration and impact of publications is not always observed.

Keywords: Bibliometric analysis; Marine Sciences; Spain; Scientific production; Collaboration; Impact.

1 INTRODUCTION

Scientific collaboration is one of the main features of current scientific activity. It has been observed anincrement in the collaborative work during the last decades among the different regions, countries andresearch fields (Sonnenwald, 2007). The growing complexity and need of specialization in the scientific work demands the participation of different researchers and teams with different know-how and skills. In the same line, the necessity of sharing resources and the development of better systems of communication are some of the reasons that contribute to explain this rise of collaboration in science (Lee & Bozeman, 2005). Within the bibliometric field there is a growing interest on the study of collaboration in its different forms, for example its incidence by geographic regions and scientific disciplines (Glänzel, 2001; Zitt et al, 2000; Larivière et al, 2006), its organizational aspects (Chompalov et al, 2002), the reasons that enhance collaboration (Katz & Martin, 1997; Melin, 2000), and its benefits over the scientific activity and research performance (Herbertz, 1995; Lee & Bozeman, 2005).

The fact that collaboration is positive for science is widely accepted. From a bibliometric point of view,publications in international collaboration have been linked to better performance as measured through the impact factor of the publication journals and through the number of citations received by the publications (Narin et al, 1991; Katz & Hicks, 1997; Glänzel, 2001; Persson et al, 2004). This is the reason why many governments and funding agencies are interested in promoting collaboration, as they consider that this is beneficial for the scientific work and should be enhanced. Anyway, the scientific literature in the field also shows that the development of scientific collaboration has costs, such as those associated to management and communication problems or to transaction costs (Katz & Martin, 1997; Landry & Amara, 1998). In any case collaboration has also benefits, being these benefits variable depending on the intensity of collaboration and the scientific field (Franceschet & Costantini, 2010), with a more beneficial collaboration in experimental and natural sciences than for example in social sciences or humanities (Larivière et al, 2006). The highest benefits have been described for the international collaboration that has been related to higher number of citations and

impact, although some authors suggest that this does not mean a higher quality of the research but a higher visibility and self-citation rate of publications caused by the higher number of signing authors and centres (Herbertz, 1995).

Another important element in bibliometric studies are the different units of analysis that are studied (Tomizawa & Hayashi, 2006). In this sense, it is not the same the bibliometric analysis of a country, a university, a department, a research team or an individual researcher, as the validity and possibilities of the bibliometric indicators chosen are also different. For this reason, in the bibliometric scientific literature different levels of analysis are contemplated depending on the aggregation level of the unit under analysis (Luukkonen-Gronow, 1987). Vinkler (1988) has established three main levels of analysis: macro, meso and micro, although according to the same author the level depends also on the system analyzed, in a way that an institute in one system can be micro level, while in another one it can correspond to a macro or meso level. Generally speaking, macro level deals with studies that focus on the analysis of big units such as countries, scientific disciplines and global sets of publications. Meso level includes studies that focus on the analysis of medium size units such as academic sectors, research institutes, etc. Finally, micro level studies deal mainly with the analysis of individual scientists and research teams.

However, these levels are not completely independent one from each other and they have some degree of interaction in the framework of the so-called “top-down” and “bottom-up” approaches (van Leeuwen, 2007). In the “top-down” approaches the data collection for the analysis is delimited from a macro-level perspective (e.g. a country or a region) or meso-level (e.g. a university), and it is possible to descend in the analysis to other aggregation levels (e.g. universities, departments, research teams and even individual scientists). It is important to highlight that top-down analyses have descriptive and monitoring validity but they have less research assessment power. If more evaluative studies are meant, then “bottom-up” approaches should be used. Bottom-up approaches start with the data collection at the micro levels (e.g. individual scientists or research teams). This type of approach requires a higher precision in the collection and verification

of the data in order to ensure their validity for research assessment purposes. Additionally, from a bottom-up approach it is possible to go up to the higher levels through the aggregation of data, being thus also possible to carry out meso and macro-level studies (for example the study of a university by the aggregation of all the publications done by the researchers working there). In this sense, in the bottom-up approach when climbing up in the aggregation level it is possible to include publications and data that wouldn't be analyzed from the perspective of the top-down analysis, including for example publications that the authors have produced out of their current institutions or countries of work, thus giving a higher analytical capacity to this approach.

In this study we focus on the top-down perspective, starting from the whole production done in Spain in the field of Marine Science and going down analyzing other lower aggregation levels. Thus, the main novelty of this study is that it presents a multi-level analysis of the effects of collaboration over the impact of the different aggregation levels in order to disentangle the potential benefits that scientific collaboration has over the impact of these different aggregation levels. In this sense, the top-down approach presents the advantage that makes it possible to detect potential divergences in the assumptions done generally for collaborative work in bibliometric research.

2 OBJECTIVES

This study focuses on the analysis of research collaboration in Spanish scientific publications during the period 1994-2004 in the area of Marine Science. This area is very interdisciplinary and presents a great importance due to the necessity of achieving a better understanding of our oceans and seas. Different papers have studied bibliometrically the scientific landscape in this area (and related topics) in different countries (Insua & Tortosa, 1997; Gattuso et al, 2005; Eto, 1999; Tapaswi & Maheswarappa, 1999; Pudovkin & Fuseler, 1995; Dastidar, 2004; Dastidar & Ramachandran, 2005; Bird, 1997; Leta & Lewison, 2003).

In this study the collaborative profile of research in the area is analyzed by means of bibliometric indicators.Several research questions are pointed out:

- How often do Spanish researchers in Marine Science cooperate with foreign researchers?
- Is international collaboration related to publications of higher impact and prestige at all aggregationlevels?
- Are there differences in the effect of collaboration (and especially international collaboration) at alllevels of aggregation?

3 METHODOLOGY

Scientific publications of Spanish researchers in the Science Citation Index (SCI), CD-ROM version, duringthe period 1994-2004 were downloaded. The SCI-CD-ROM is a multidisciplinary database which coversmore than 3700 journals selected according to their formal and scientific quality. The records downloaded were organized in a relational database, in which a standardization of the address information was 3 performed following Fernández et al (1993) guidelines. The original bibliographic records from the CD-ROM version of SCI were complemented with the total number of citations (same period 1994-2004) and the impact factor of the publication journals, coming from the web version (Web of Science) of the SCIE (Science Citation Index Expanded) and the Journal Citation Reports (JCR). The matching between the two sets of data was performed considering the recommendations of Costas & Iribarren-Maestro (2007).

Delimitation of the Marine Science area

In order to get a proper delimitation of the field of Marine Science as complete as possible, a mixed filter has been developed (Duarte et al, 2006; Costas & Bordons, 2008) combining a set of selected keywords and considering the suggestions from a group of experts in the area.

The top down analysis was performed by delimiting the publications in Marine Science with “Spain” in the country field of the affiliation address of any of the co-authors of the publications. All the Spanish addresses in this set were unified, and sector and institutional codes were provided to all the addresses detected being able to identify

them univocally. Finally a set of the 25 most productive individuals working in these affiliations was detected (researchers with 40 or more publications).

Activity and impact indicators

The Spanish scientific activity in the Marine Science area is analysed and main institutional sectors, centresand researchers are identified being their activity described through the following indicators:

a) Total number of publications.

b) Total number of citations received by these publications.

c) Citations per Publication rate.

d) Mean Impact Factor, this is the average value of the Impact Factor (IF) of the publication journals of the papers.

e) Normalized Journal Position (NJP) (Bordons & Barrigón, 1992). The NJP is calculated considering the position of every journal in its JCR subject category by decreasing order of impact factor divided by the total number of journals in that JCR subject category. This indicator ranges between 0 and 1, being an indicator of the importance and visibility of the journal in its field.

NJP = 1- (position of the journal in the subject category / total journals in the area)

The statistical analysis of data was performed with SPSS (version 17). Differences between means were analyzed through the ANOVA and U-Mann Whitney tests, considering statistical significant differences when $p<0.05$.

Analysis of collaboration and its effects over citations and journal impact

In this analysis, collaboration has been studied from an institutional point of view, considering the number of centres per publication and the presence of Spanish and international centres in the address field of the publications. In this line, publications have been classified in:

a) Publications without collaboration: publications published by just one centre.

b) Publications in national collaboration: two or more Spanish centres.

c) Publications in international collaboration: at least one centre is from a foreign country.

Mixed publications (mix of national and international collaboration) have been included under the "international collaboration" label as this type of collaboration was considered the most important.

In order to study the benefits of collaboration over the impact and visibility of publications, we have used a variant of the "GIFCOL Index" ("Gain in Impact through Foreign Collaboration") originally proposed by Basu & Aggarmal (2001). This index was originally developed for the analysis of international collaboration, but in this paper it has been applied to the analysis of the three different types of collaboration previously defined (i.e. no collaboration, national collaboration and international collaboration). Thus, in this paper we have renamed it as GICOL ("Gain in Impact factor through Collaboration") and the formulation of this indicator has been slightly changed as follows (being A any unit of analysis):

(ΣImpact Factor (or citations) of publications in (any type of) collaboration of A / ΣIF total publications of A) x 100 – (N. publications in (any type of) collaboration of A / N. total publications of A) x 100

In addition, a variant of this index has been proposed: the (GCCOL) "Gain in Citations through Collaboration" with the aim of calculating the gain in citations for the different types of collaboration.

Both indicators take into account the proportion of papers that are collaborative and measure the difference between this and the corresponding proportional gain in impact factor or citations. If there is no difference between the average impact factor or citations of papers in collaboration and the rest, this measure will be 0. Positive values indicate a gain in impact factor or citations through collaboration, while negative values indicate the contrary (see Basu & Aggarwal, 2001).

The potential benefits of collaboration over the impact of the scientific production are analyzed in four different levels of aggregation:

- Spain (as a whole);
- institutional sectors;
- the most productive research centres;

- and the most productive researchers.

As the most productive centres we have considered those with more than 110 publications, while the most productive researchers were those authors with 40 or more publications (25 researchers).

4 RESULTS

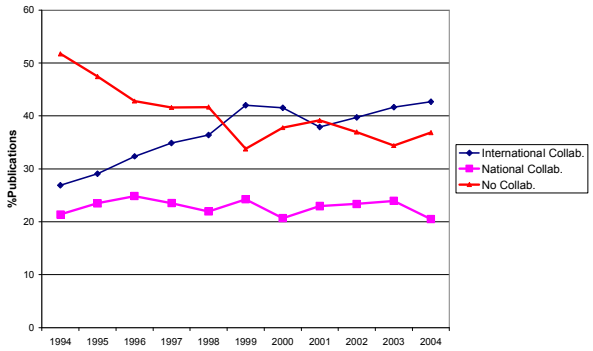
The Spanish scientific production in Marine Science was composed by 6,898 publications in the period 1994-2004, showing a positive increment, higher than the one described for the whole Spanish production duringthe same period and database (90% vs. 54%). Marine Science publications represented 2.5% of all the Spanish production in 1994 growing up to the 3.3% at the end of the period, what means a clear progression of this area in Spain, which has been described in previous studies (Duarte & Tintoré, 1996; Duarte et al, 2006).

1. Scientific collaboration at the macro-level: Spain

During this period, 60% of the publications were written with some degree of institutional collaboration versus 40% of publications with just one centre (i.e. no collaboration). Spanish researchers collaborated with at least one foreign centre in 38% of all publications (the remaining 22% of publications had only national collaboration).

Along the period of analysis, the percentage of publications in collaboration tends to grow faster than publications without collaboration (increments of 160% and 41% respectively). In fact, the percentage of publications in collaboration increased from 48% in 1994 to 63% in 2004, while the percentage of publications with no collaboration decreased from 52% to 37% during the same period. The highest increment was for publications in international collaboration (27% of publications in 1994 and 43% in 2004) (see Figure 1).

Figure 1. Temporal evolution of publications by type of collaboration.



The scientific production of Marine Science shows a mean of around 4 authors and 2 centres per publication, values very similar to those obtained by Gattuso et al (2005) who observed a mean of 3.2 authors in 2002 for the area of coastal biogeochemistry, or Leimu & Koricheva (2005) who confirmed a mean of 2.8 authors and 1.6 centres in 2000 for the area of Ecology. Publications in international collaboration show a higher number of authors and centres per publication than publications in national or without collaboration (Table I).

Table I. Number of authors and centres per publication by type of collaboration

	Intern. Collab.	Nat. Collab.	No collab.	Total	Sig.
N.Authors/Pub.	5.26±4.59 Med=4 (1-147)	4.24±1.75 Med=4 (1-19)	3.16±1.39 Med=3 (1-13)	4.20±3.18 Med=4 (1-147)	p<0.001
N.Centres/Pub.	3.21±1.99 Med=3 (2-32)	2.32±0.63 Med=2 (2-7)	1 Med=1 (1-1)	2.15±1.63 Med=2 (1-32)	p<0.001

Data presented as: mean ± standard deviation; Med=median, (min-max)

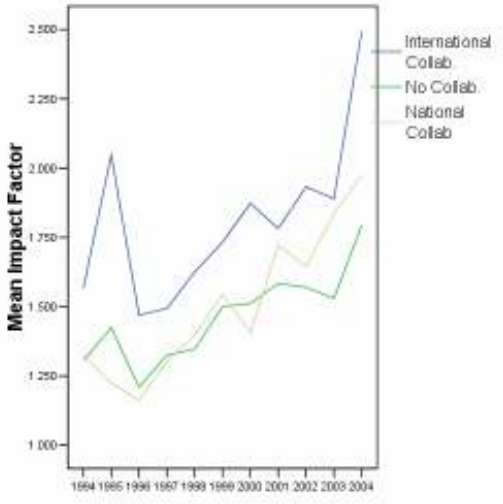
The impact of the publications by type of collaboration is presented in Table II. It can be observed that publications in international collaboration tend to be published in journals of higher impact factor than publications in national collaboration or with no collaboration and they receive more citations than the latter (p<0.001)

Table II. Impact and collaboration of Spanish publications in Marine Science

	Intern. Collab.	Nat. Collab.	No collab.	Total	Sig.
Citations/Publication	9.50±13.50 Med=5 (0-133)	7.06±9.05 Med=4 (0-90)	7.31±10.08 Med=4 (0-199)	8.06±11.28 Med=4 (0-199)	p<0.001
Mean Impact Factor	1.862±2.696 Med=1.403 (0-32.182)	1.555±1.594 Med=1.297 (0.179-30.979)	1.488±1.313 Med=1.373 (1.096-29.491)	1.643±1.977 Med=1.308 (0-32.182)	p<0.001
Normalized Journal Position	0.70±0.22 Med=0.75 (0-0.99)	0.68±0.23 Med=0.73 (0.01-0.99)	0.67±0.24 Med=0.68 (0-0.99)	0.68±0.23 Med=0.73 (0-0.99)	p<0.001

During the last years there was a growth in the impact factor of publication journals (both in the mean and the median). This can be explained by the tendency of Spanish researchers to publish in journals of higher impact factor, stimulated by the different evaluation processes existing in Spain (Jiménez Contreras et al, 2003) that encourage the publication in high impact factor journals, although the trend towards a global increment in the impact factor described by Ma & Guan (2005) cannot be discarded also as an influential element. Anyway, our data suggest that the research performed with international collaboration is published in better journals than research in national or without collaboration (Figure 2).

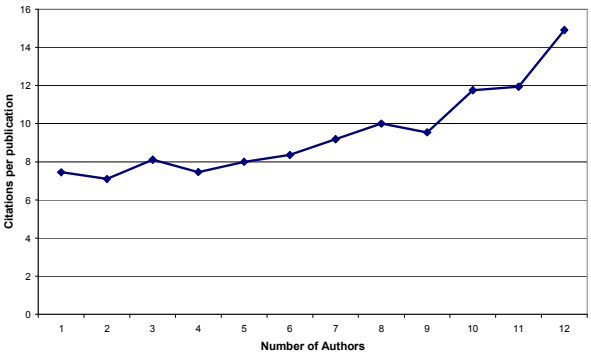
Figure 2. Evolution of the mean of Impact Factor by type of collaboration

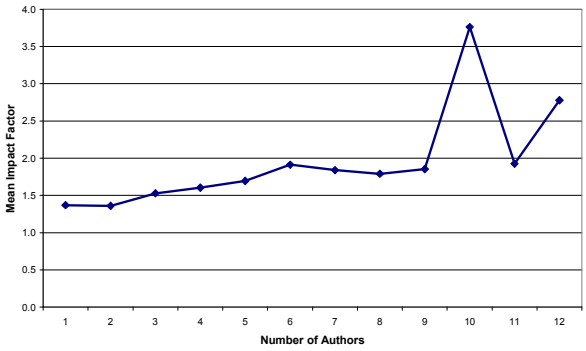


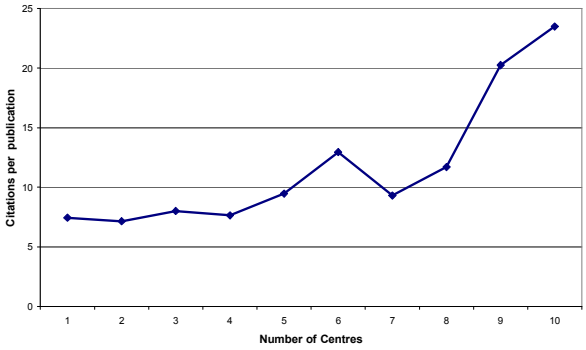
The relationship between the impact of the publications and their average number of authors and centres is presented in Figure3. It can be seen how both the citations per

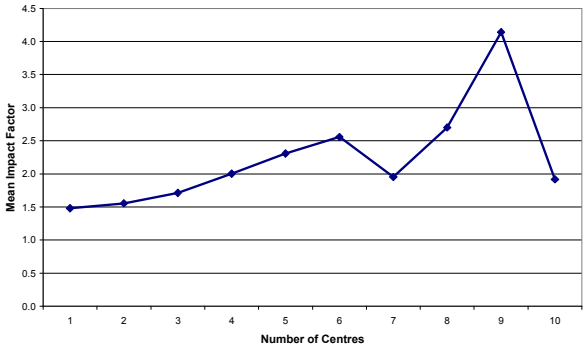
publication and the mean of the Impact Factor tend to increase with the number of authors and centres per publication.

Figure 3. Citations per publication and Mean Impact Factor by number of Authors and Centres per publication









2. Scientific collaboration at the meso-level: institutional sectors

The distribution of the scientific production by institutional sectors is shown in Table III, where the profile of collaboration for each of the main institutional academic sectors in Spain is presented. The University is the main producer of publications (69%), followed by the Spanish National Research Council (CSIC) (34%) and other Public Research Institutes (PRI) (6%), which include among others the Spanish Oceanographic Institutes. The CSIC is one of the Spanish research organizations with the highest rate of international collaboration (43%), only surpassed by the private companies (more than 49% of their production in international collaboration). The most active companies in Marine Science are several pharmaceutical companies (i.e. Pharmamar) as well as companies of fish farm and aquaculture.

Table III. Distribution of publications by institutional sectors and type of collaboration

Institutional Sectors	N.Pubs.		%Doc. Collab.		
	N. Pubs.	%	Int. Collab.	Nat. Collab.	No Collab.
University	4774	69.21	33.57	28.29	38.12
CSIC	2338	33.89	43.41	25.49	31.09
Other PRI	424	6.15	33.73	48.59	17.69
Public Administration	339	4.91	29.50	56.93	13.57
Companies	181	2.62	49.17	42.54	8.29
Total	6898 (*)	100	37.92	39.29	22.79

(*) 225 publications have been excluded as they belong to the heath sector, foundations and other marginal institutional sectors that have a very limited activity in this area.

The bibliometric performance of the main institutional sectors by the type of collaboration is described in Table IV. International collaboration is associated with papers

in journals of higher impact factor as well as with more citations per publication in all the institutional sectors (statistically significant differences in nearly all the cases). It is interesting to observe that although the University is the main producer in Marine Science in Spain, the highest number of citations and citations per publication corresponds to the CSIC.

Table IV. Activity by Institutional sectors and type of collaboration.

Sector	Indicators	Int. Collab.	Nat. Collab.	No Collab.	Total	Sig.
University	Citations/Publication	8.59±12.39 Med=5 (0-13)	6.82±8.75 Med=4 (0-90)	6.23±8 Med=4 (0-100)	7.19±9.92 4 (0-133)	0.001
	Mean Impact Factor	1.78±2.4 Med=1.38 (0-32.18)	1.53±1.46 Med=1.28 (0.069-30.979)	1.43±0.94 Med=1.24 (0.034-14.629)	1.576±1.702 1.291 (0-32.182)	0.001
	Normalized Journal Position	0.68±0.23 Med=0.74 (0-0.99)	0.67±0.23 Med=0.73 (0.014-0.99)	0.65±0.24 Med=0.7 (0-0.9921875)	0.67±0.24 0.72 (0-0.99)	0.001
CSIC	Citations/Publication	11.15±14.71 Med=6 (0-129)	9.01±10.56 Med=6 (0-88)	10.45±13.96 Med=6 (0-199)	10.39±13.55 6 (0-199)	NS
	Mean Impact Factor	1.96±2.884 Med=1.47 (0.185-32.182)	1.62±1.864 Med=1.3 (0.179-29.491)	1.68±1.998 Med=1.34 (0.084-29.491)	1.788±2.402 1.365 (0.084-23.182)	0.001
	Normalized Journal Position	0.73±0.21 Med=0.76 (0.05-0.99)	0.69±0.23 Med=0.73 (0.01-0.99)	0.71±0.23 Med=0.75 (0.01-0.99)	0.71±0.22 0.75 (0.01-0.99)	NS
Other PRI	Citations/Publication	9.77±14.29 Med=5 (0-106)	6.38±7.32 Med=4 (0-40)	4.59±4.58 Med=3 (0-21)	7.17±10.04 4 (0-106)	0.017
	Mean Impact Factor	1.86±3.24 Med=1.3 (0.329-28.833)	1.37±0.994 Med=1.17 (0.24-10.12)	1.23±0.579 Med=1.16 (0.306-3.336)	1.510±2.035 1.2 (0.24-28.833)	0.012
	Normalized Journal Position	0.73±0.2 Med=0.77 (0.1-0.98)	0.66±0.21 Med=0.7 (0.02-0.97)	0.63±0.23 Med=0.69 (0.03-0.97)	0.68±0.21 0.71 (0.02-0.98)	0.005
Public Administration	Citations/Publication	9.2±9.53 Med=6.5 (0-44)	6.94±8.08 Med=4.5 (0-48)	5.09±5.4 Med=3 (0-22)	7.36±8.33 5 (0-48)	0.008
	Mean Impact Factor	2±3.92 Med=1.18	1.44±0.775 Med=1.24	0.97±0.462 Med=0.98	1.54±2.25 1.18	0.001

Sector	Indicators	Int. Collab.	Nat. Collab.	No Collab.	Total	Sig.
		(0.327-28.956)	(0.259-3.81)	(0.229-2.085)	(0.229±28.956)	
	Normalized Journal Position	0.73±0.19 Med=0.75 (0.08-0.98)	0.7±0.22 Med=0.75 (0.07-0.98)	0.57±0.27 Med=0.7 (0.08-0.93)	0.69±0.23 0.75 (0.07-0.98)	0.001
Companies	Citations/Publication	7.34±13.09 Med=2 (0-72)	4.89±7.09 Med=2 (0-35)	6.8±10.69 Med=2 (0-35)	6.24-10.69 2 (0-72)	NS
	Mean Impact Factor	2.7±3.3 Med=2.38 (0.278-28.833)	1.7±1.414 Med=1.34 (0.329-10.12)	1.06±0.538 Med=0.92 (0.246-2.331)	2.14±2.55 1.536 (0.246-28.833)	0.001
	Normalized Journal Position	0.75±0.19 Med=0.81 (0.09-0.98)	0.71±0.24 Med=0.78 (0.1-0.98)	0.64±0.27 Med=0.67 (0-0.96)	0.73±0.22 0.81 (0-0.98)	NS

In general all the sectors take some advantage of the activity in international collaboration. The “gain in impact factor” and the “gain in citations” indicators are shown for the different types of collaboration in Table V.

Table V. Gain in Impact Factor and Citations by institutional sectors and type of collaboration

Institutional sectors	N. Pubs.	GICOL-No collab.	GCCOL-No collab.	GICOL - NC	GCCOL - NC	GICOL - IC	GCCOL - IC
University	4774	-3.53	-5.12	-0.81	-1.13	4.32	6.23
CSIC	2338	-2.11	0.38	-2.42	-3.17	4.53	2.78
Other PRI	424	-3.07	-6.51	-4.89	-5.41	7.97	11.92
Public Administration	339	-5.28	-3.82	-3.97	-3.51	9.25	7.33
Companies	181	-4.14	0.76	-8.75	-9.27	12.89	8.50

Notes: GICOL=gain in impact factor; GCCOL =gain in citations; -No collab.=No collaboration; -NC=National Collaboration; -IC=International Collaboration

According to Table V, all institutional sectors gain in impact factor and in citations when international collaboration is considered. The major gain in impact factor associated to the international collaboration is detected in the sectors of Companies and Public Administration, while Other PRI are the most benefited in citations with international collaboration. Papers in national collaboration and with no collaboration present a negative gain in terms of both impact factor and citations, with the only exception of the CSIC and the sector of Companies, in which there is a slight gain in the publications with no collaboration. In any case, at this level of analysis, it can be straightforwardly stated that

international collaboration has a clear positive effect over the impact of publications.

3. Scientific collaboration at the meso-level: centres with high levels of production

In this section, the influence of collaboration on the impact of the research is analysed at the level of the Spanish centres and institutes that have done most of the Spanish production in Marine Science. The most productive Spanish research centres (with more than 110 publications) in the area are presented in Table VI. Among the most productive centres it can be mentioned the *Instituto de Ciencias del Mar de Barcelona*, the Faculty of Biology of the *Universidad de Barcelona* and the *Instituto de Investigaciones Marinas de Vigo*, which present the highest numbers of publications and total citations.

In general, a trend towards publishing in journals of intermediate-high impact factor within their fields (Normalized Journal Position>0.7) can be observed. The level of international collaboration is relatively high for most of the centres, especially for those of the CSIC (around 30%), but lower levels of international collaboration can be also distinguished in a few centres, especially in some of the universities (e.g. U. La Coruña or the U. Murcia with less than 20% of production in international collaboration).

Table VI. Activity, impact & profile of collaboration of the most productive Spanish research centres in Marine Science (≥110 doc.)

Centres	N. Publications	Impact indicators				Profile of collaboration		
		Total Citations	CPP	NJP	Mean Impact Factor	%No collab.	%Nat. Collab.	%Internat. Collab.
I.Cienc.del Mar CSIC,Barcelona	545	6615	12.14	0.73	1.817	31.01	24.59	44.4
Fac.Biol.U Barcelona	399	4492	11.26	0.7	1.708	26.07	36.09	37.84
I.Inv.Marinas CSIC,Vigo	391	3409	8.72	0.71	1.647	37.08	25.32	37.6
C.And.Sup.Estud.Mar, U.Cádiz	306	2129	6.96	0.59	1.433	30.39	39.87	29.74
Fac.Cienc.U.Málaga	296	2158	7.29	0.65	1.576	32.43	35.47	32.09
C.Est.Avanz.Blanes CSIC,Girona	257	3724	14.49	0.72	1.765	25.29	28.02	46.69
Edif.Cienc.Exper.U.Vigo	240	1722	7.18	0.7	1.708	27.5	36.25	36.25
Fac.Biol.U.Santiago	205	1382	6.74	0.71	1.632	35.12	40.98	23.9
I.M.Est.Avanz.CSIC–U.I.Balears	199	1469	7.38	0.73	2.241	17.59	31.16	51.26
Fac.CC.Mar.U.Las Palmas	192	1612	8.31	0.66	1.662	39.58	24.48	35.94
I.Cienc.Marinas CSIC,Cádiz	168	1452	8.64	0.57	1.235	27.98	43.45	28.57
I.Acuic.T.Sal CSIC,Castellón	167	1962	11.75	0.69	1.467	33.53	25.15	41.32
Fac.Cienc.Tecnol.U.P.Vasco	165	1253	7.59	0.65	1.434	51.52	18.18	30.3
Fac.Biol.U.Valencia	159	947	5.96	0.61	1.219	32.7	35.85	31.45
Fac.Cienc.U.Granada	153	1263	8.25	0.69	1.516	17.65	42.48	39.87
Fac.Biol., U. Murcia	144	1158	8.04	0.68	1.606	56.94	23.61	19.44
Fac.Cienc.U.La Coruña	136	880	6.47	0.65	1.485	50	32.35	17.65
Fac.Biol.U.Sevilla	121	500	4.13	0.47	1.02	39.67	32.23	28.1
Fac.Biol.U.Oviedo	117	702	6	0.64	1.351	42.74	25.64	31.62
Fac.Geol.U.Barcelona	115	1015	8.83	0.71	2.23	7.83	24.35	67.83

As for the institutional sectors, table VII presents the gains in impact factor and citations for the different centres considering their share of production across the different types of collaboration. As it can be seen, for most of the centres, their production done in the framework of international collaboration is related to gains in impact factor and citations, although here we start to detect some exceptions as it can be also observed in Figure 4, where some of the centres have in fact a negative gain in citations in their activity in international collaboration.

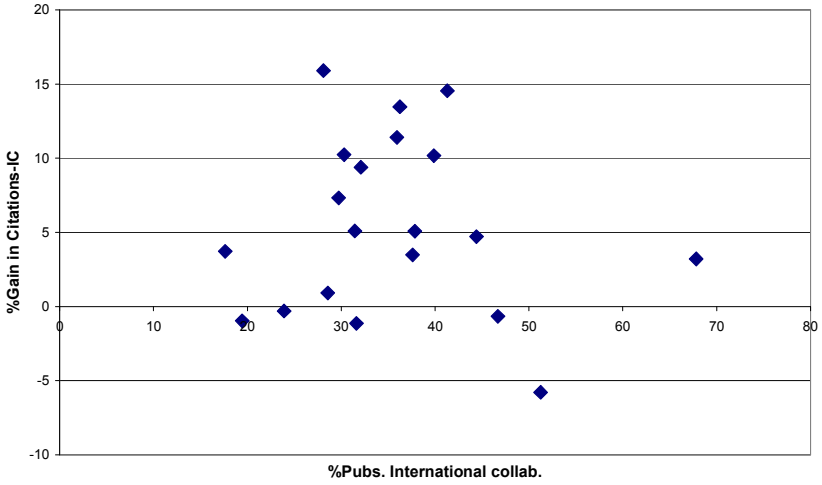
Table VII. Gain in Impact Factor and Citations by centre and type of collaboration

Centres	N.Pubs.	GICOL-No collab.	GCCOL-No collab.	GICOL - NC	GCCOL - NC	GICOL - IC	GCCOL - IC
I.Cienc.del Mar CSIC,Barcelona	545	-1.02	-3.57	1.94	-1.14	-0.93	4.71
Fac.Biol.U Barcelona	399	-3.34	0.34	-2.98	-5.41	6.32	5.08
I.Inv.Marinas CSIC,Vigo	391	-10.55	-0.30	-3.18	-3.17	13.72	3.47
C.And.Sup.Estud.Mar, U.Cádiz	306	-1.44	-11.70	-4.90	4.38	6.33	7.32
Fac.Cienc.U.Málaga	296	-3.64	-9.73	-1.84	0.35	5.49	9.38
C.Est.Avanz.Blanes CSIC,Girona	257	8.47	3.63	-4.29	-2.96	-4.18	-0.67
Edif.Cienc.Exper.U.Vigo	240	-3.10	-12.87	1.41	-0.59	1.69	13.46
Fac.Biol.U.Santiago	205	-1.29	0.33	4.02	-0.02	-2.74	-0.31
I.M.Est.Avanz.CSIC-U.I.Balears	199	-3.08	1.95	-10.05	3.83	13.13	-5.78
Fac.CC.Mar.U.Las Palmas	192	-9.78	-15.14	-6.06	3.75	15.84	11.40
I.Cienc.Marinas CSIC,Cádiz	168	-3.94	-1.25	2.65	0.35	1.30	0.91
I.Acuic.T.Sal CSIC,Castellón	167	-1.31	-6.72	-0.88	-7.82	2.19	14.54
Fac.Cienc.Tecnol.U.P.Vasco,Bilbao	165	-1.82	-1.56	0.18	-8.68	1.64	10.24
Fac.Biol.U.Valencia	159	-5.47	0.14	1.38	-5.23	4.08	5.09
Fac.Cienc.U.Granada	153	-4.04	-4.19	2.39	-5.98	1.65	10.17
Fac.Biol., U. Murcia	144	5.80	1.00	-0.44	-0.04	-5.36	-0.96
Fac.Cienc.U.La Coruña	136	-5.59	-1.70	4.33	-2.01	1.26	3.72
Fac.Biol.U.Sevilla	121	-7.33	-5.87	4.59	-10.03	2.74	15.90
Fac.Biol.U.Oviedo	117	-3.08	-3.70	2.28	4.84	0.80	-1.14
Fac.Geol.U.Barcelona	115	-4.54	0.45	2.66	-3.66	1.88	3.21

Notes: GICOL=gain in impact factor; GCCOL =gain in citations; -No collab.=No collaboration; -NC=National Collaboration; -IC=International Collaboration

As it can be seen in Figure 4, the main part of the centres shows a positive gain although the correlation between both variables is not very high, and there are 5 centres that present a negative gain in citations in their production with international collaboration. This lack of correlation implies that not all centres are benefited by international cooperation at the same degree. Several factors such as the relevance of the research topic, the prestige/excellence of the partner, the proper management of the collaboration or the already high level of some of the Spanish research centres could be behind this effect.

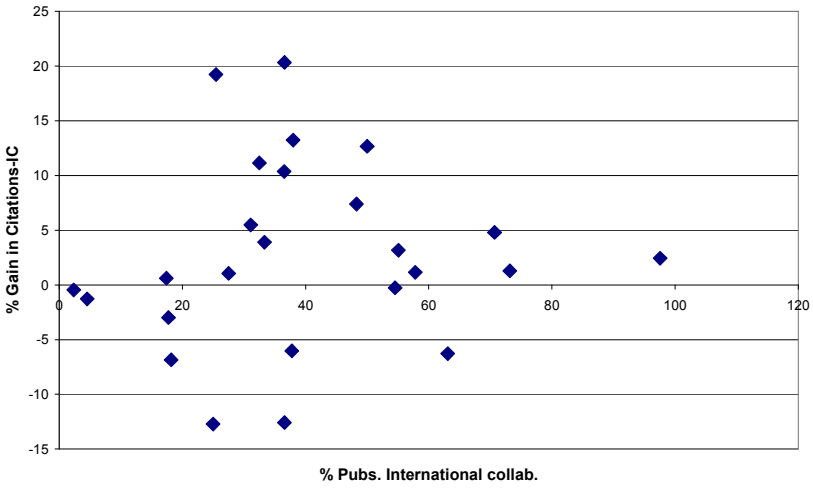
Figure 4. Relationship between international collaboration and gain in citations – research institutes



4. Collaboration at individual level (micro-level)

The last step of the analysis focuses on the study of the benefits of collaboration at the individual level. In this analysis, again the idea that some researchers take more advantage than others of the international collaboration is tested. Thus, the gains in citations and impact factors have been analyzed at the individual level for the 25 most productive researchers in Marine Science in Spain (Figure 5).

Figure 5. Relationship between international collaboration and gain in citations – individual authors



The same situation as previously observed at the level of research centres is observed now in Figure 5 for individual researchers. Not all individuals obtain the same gain from international collaboration and even several authors present negative gains with this type of collaboration. In general, it can be seen how there is not a clear pattern of gain in citations among researchers, although the main part of them tend to be benefited at some degree by international collaboration.

In summary, all the results suggest that as we go down in the level of aggregation of the units of analysis (from the whole country to institutional sectors, to research centres and to individual scientists), collaboration and particularly international collaboration shows less clear beneficial effects over the impact of publications, thus suggesting that for the lower aggregation levels (e.g. centres or individuals), international collaboration is not always a guarantee of higher impact as it is compared to the more macro levels (the whole country or institutional sectors), thus supporting the idea of the necessity of introducing a more critical look over the role of collaboration regarding the different levels of analysis.

5 CONCLUSIONS

During the period 1994-2004, Spanish research in Marine Science has observed an

important growth (98%), higher than the increment described for the global Spanish production in all areas. Scientific collaboration has played an important role in the growing trend of production as the number of publications in collaboration has increased around 160% and the number of publications in international collaboration has grown 215%. It should be remarked that this increment in the number of publications is related to a growing orientation towards publishing in journals of major international prestige.

The results of this study show that at macro and meso levels, international collaboration is related to publications in journals of greater prestige and to publications which receive a higher number of citations than those with national collaboration or without collaboration. This general trend of publications in collaboration and especially in international collaboration has been also observed at macro levels by Ma & Guan (2005) for the collaboration in Chinese publications or by Katz & Hicks (1997) for UK publications.

However, this positive effect of international collaboration is not observed so clearly when we descend in the level of aggregation of the unit of analysis such as research centres or individual scientists. In this sense, it has been observed that there are differences in the gain of citations and impact factor of publications in international collaboration among the different research centres and individuals, what means that not all centres and all individual researchers are benefited at the same degree by international collaboration. This observation that international collaboration does not always benefit the impact of publications has been already suggested by other authors (Avkiran, 1997; Herbetz & Müller-Hill, 1995; Herbertz, 1995). Glänzel & Schubert (2001) affirm that although in general terms international collaboration presents better results, some countries are not always benefited by this type of collaboration, suggesting the existence of centres “attractive” and “repulsive” of collaboration. Van Leeuwen & Tijssen (2007) proposed that some countries with a high degree of scientific development are not benefited by collaboration as some other countries less developed scientifically. Leimu & Koricheva (2005), in a topic closely related to Marine Science as Ecology also proposed that collaboration has minor effects and not always positive over the rates of citations of publications.

Among the explanations for this situation, it can be mentioned the statement made by Lee & Bozeman (2005) that a particular collaboration can make a reduction in the productivity of some specific individuals but an increment for other individuals or collectives. Following the ideas of Pravdic & Oluic-Vukovic (1986) collaboration can be affected by the situation that scientists who cooperate with more productive researchers tend to increase their personal productivity, while when the same scientists cooperate with other scientists of lower productivity there can be a decrease in their productivity level. One similar hypothesis has been proposed by Bordons et al (1993) for more peripheral countries, questioning if international collaboration benefits all collaborations at the same degree or if it benefits more the less developed countries. On the other hand, Lee & Bozeman (2005) suggest that the increment of productivity in function of the collaboration depends on the strategy of collaboration; a similar statement was made by Basu & Aggarwal (2001) who observed that Indian private hospitals were more benefited by international collaboration than more prestige public medical centres. According to all these, we can question if collaboration is more beneficial for those scientists who still have "room" for scientific improvement and less beneficial for those researchers that are already working at a very high level where improvement is more difficult.

Other possible explanation for these differences is that they can be caused by the effects of a bad management of the collaborative activity (wrong communication, wrong management of the research, etc.), a bad selection of the research lines or just that collaboration does not respond to the initial expectations (Cullen et al, 1999). The results of this study raise the necessity of deepening into the aspects and factors that favour the beneficial collaboration in terms of citations and impact from a more bottom-up perspective. Moreover, although micro-level and bottom-up analyses present a high complexity and difficulties in their development (Costas & Bordons, 2005), they are highly useful as they provide valuable information for policy makers and researchers (Jiménez-Contreras et al, 2011), allowing them to know if their collaborative strategies are achieving the expected results or if these strategies need to be changed.

Finally, considering all these results, research policies that encourage international

collaboration should bear in mind that this type of collaboration is not always a recipe for scientific impact and that collaboration should be a natural result of other scientific strategies in the quest of research quality.

ACKNOWLEDGMENTS

The author wants to thank Prof. María Bordons from the CCHS-CSIC for her comments on an early version of this paper, as well as to all the experts who collaborated in the obtention and delimitation of the data, and especially to Prof. Carlos M. Duarte from the IMEDEA-CSIC for all the help and orientation along the development of this study.

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