

Scientometric analysis of coastal eutrophication research during the period of 1993 to 2008

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Abstract No studies were reported on the field of coastal eutrophication research by using bibliometrics. The objective of this study was to evaluate the coastal eutrophication research performance based on all the related articles in Science Citation Index databases from 1993 to 2008. Document type, publication output, authorship, keywords, publication pattern, country, and institute of publication were analyzed. The USA contributed 35.0% of total articles where the ten major industrial countries accounted for the majority of the total production. An indicator citation per publication was presented in this study to evaluate the impact of number of authors, institutes, countries, and journals. The mean value of citation per publication of collaborative papers was higher than that of single country or institute publications. Collaboration trend was toward multi-authors, multi-institutes and multi-countries papers. This was coincident with the research trends of coastal eutrophication, which was thought to be a component of global change. Additionally, keywords analysis was used to indicate the formation and shift of hot research.

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1 Introduction

Eutrophication is the enrichment of water as a result of an increase in nutrients (Nixon 1995), which can have a negative impact on the coastal environment. It breaks the ecological balance of the coastal waters, making the original ecosystem structures changed and functions degenerated (Duarte 1995; Capriulo et al. 2002), or even increasing incidences and duration of harmful algal blooms (Riegman et al. 1992; Anderson et al. 2002). In the past decades, eutrophication has become a major environmental problem in many coastal ecosystems worldwide (Vanbennekorn et al. 1975; Lee and Arega 1999; Bricker et al. 1999; Cloern 2001) and has consequently received considerable attention on the political agenda.

Bibliometrics is a research method used in library and information sciences, which utilizes quantitative analysis and statistics to describe distribution patterns of publications within a given topic, field, institute, or country. One common approach to bibliometric research is to use the Science Citation Index (SCI) that traces publications of the Institute for Scientific Information (ISI). The SCI by the bibliometric analysis has been widely used to investigate topics in many fields, such as medical topics (Chiu et al. 2004; Li et al. 2009) and science and engineering fields (Huang et al. 2008; Xie et al. 2008), additionally Fourqurean et al. use a bibliometric method to evaluate the health of 'Estuaries and Coasts' and examine its growth in size and reputation during the process of changing its name (Fourqurean et al. 2008).

The purpose of this study was to evaluate the coastal eutrophication research performances based on 3,654 articles published in Science Citation Index Expanded between 1993 and 2008. Similar to the journal impact factor (IF) defined by SCI, an indicator named citation per publication (CPP) was used to characterize the performance of coastal eutrophication research. Furthermore, other parameters, including year of publication, authorship, inter-institute collaboration, international collaborations, and keyword trends, were analyzed.

2 Materials and methods

Data were collected from the online version of the ISI Web of Science: SCI (Science Citation Index) in this study. All documents from 1993 to 2008 with the following keywords in topic were searched: eutroph*, hypoxia, 'nutrient enrichment', and 'seagrass decline' in one topic and coast*, bay, gulf, bight and estuary in another topic, 4,515 documents met the criteria, among which five papers were removed for duplication. Downloaded information included author(s), title, source, document type, keywords, time cited and subject category. The records were exported into spreadsheet software (Microsoft Office Excel), and additional coding was manually performed for the number of authors, institute and country of origin of the collaborators, and impact factors of the publishing journals. The IF of a journal was determined for each document as reported in the 2008 edition of the Journal Citation Reports (JCR). The address of each author was used to distinguish the collaboration type in institute or country. If one paper was done by the

author(s) from one institute (country) that would be assigned as “independent”, others would be assigned as “inter-institute collaboration” or “international collaboration”. Articles originating from England, Scotland, Northern Ireland, and Wales were grouped under the UK heading.

The number of times cited for a publication is an important indicator that assessed the impact of a publication. However, the total times cited for a publication is highly correlated with the length of time since its publication. Figure 1 shows the variation with article life of citation per publication for all the 3,654 articles and all documents life of citation per publication for all the 4,510 documents. It can be seen that the citation per publication of the all documents and the article type reached maximum in the 6th year since its publication, and began to decrease thereafter. The peak position depends on the research discipline and was about 2 years in the case of homeopathy (Chiu and Ho 2005) or was about 4 years in the case of biosorption technology in water treatment research (Ho 2008). Therefore, to adjust for bias due to differences in the length of time since publication, a new variable, TC6 (total times cited before year 6), was created to adjust for bias due to differences in the length of time since publication, similar to the journal IF defined by the JCR, the variable TC6 was used to assess the visibility of articles. A TC6 for an article published in the year 2002 would be the number of times being cited before the end of 2008 for all the articles published in 2002. With TC6, an indicator named citations per publication (CPP) was introduced. The average first 6 full year citations per publication (CPP) were defined as the ratio of the sum of TC6 for total publications to total number of papers. In some cases, we only discussed the documents published during the period from 1993 to 2002 because of no data for TC6 after 2002.

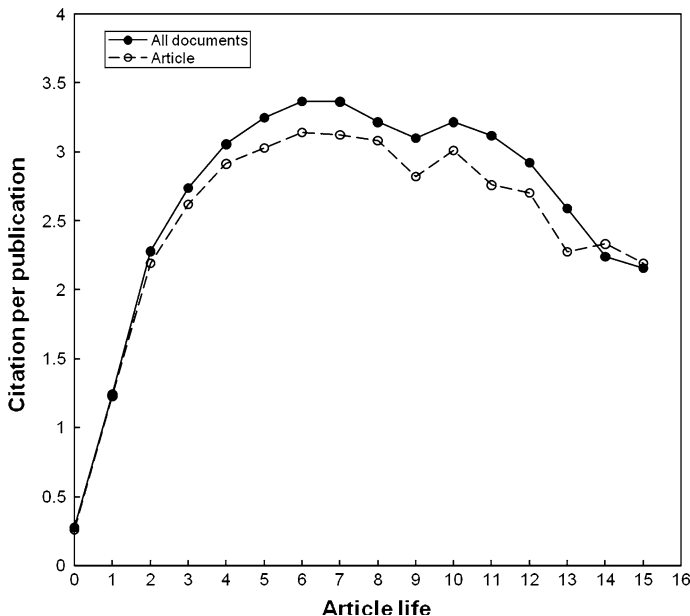


Fig. 1 The variation with article life of citation per publication for all the articles and all documents

3 Results and discussion

The total papers related to costal eutrophication research in ISI web database from 1993 to 2008 are 4,510. From the distribution analysis, 9 document types were found. The paper article was the most frequently used document type comprising 81.0% of the total productions, followed by proceedings papers (588; 13.0%), reviews (215; 4.77%), editorial materials (25; 0.554%), letters (8; 0.177%), meeting abstracts (8; 0.177%), notes (6; 0.133%), corrections (5; 0.111%), and one for addition correction. Consider citation per publication as an indicator for papers were published from 1993 to 2002, review paper had the highest value of CPP (44.3), followed by note with CPP of 19.4, and article with CPP of 15.1. Because paper articles represented the majority of the publications that were also peer-reviewed within this field, only paper articles were considered for further analysis, documents of article type were analyzed according the following types: article output, publication pattern, authorship, and institute, country, and author keywords.

3.1 Publication output

In total, there were 3,654 articles downloaded from the ISI web database from 1993 to 2008. The cumulative number of papers consistently increased during this period. Ninety-two articles were published in 1993, while the number of articles was 460 in 2008, 5 times of that in 1993.

Figure 2 shows a significant correlation between the yearly cumulative number of publications and the actual year of publications. Compared with other growth function, the relations are more in accordance with the logarithmic curve during the period of 1993 to 2000 and the exponential growth curve during the period of 2000 to 2008. The two relations have a high coefficient of determination, which were expressed using a

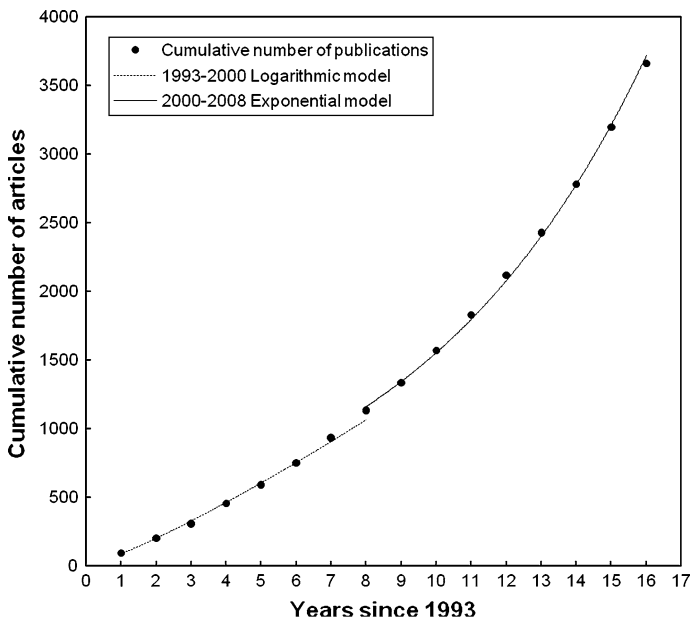


Fig. 2 Relationship between publications output and cumulative number publications

logarithmic model ($Y = 87.1X^{1.20}$, $r^2 = 0.997$) and an exponential model ($Y = 362\exp(0.146X)$, $r^2 = 0.999$), where Y is the cumulative number of publications, and X is the number of years since 1993. Both logarithmic and exponential curve-fitting methods revealed that a high growth rate was sustained for yearly publications. The difference of the cumulative trend was significant between the two periods from 1993 to 2000 and 2000 to 2008. The growth rate of the exponential model was greater than the logarithmic model. The reason may lie in two aspects. In 2000, the European Parliament and the Council adopted the European Union (EU) Water Framework Directive (WFD), which provides a framework for the protection of groundwater, inland surface waters, transitional waters (estuaries) and coastal waters (Anonymous 2000), and at the same year, National Research Council in USA published the Clean Coastal Water (NRC 2000). These drove governments and society pay greater attention on the serious eutrophication symptoms along the world coastlines in general.

3.2 Publication patterns

A total of 1,570 articles were downloaded from ISI web database from 1993 to 2002, which were distributed in 289 journals. Among these journals, 133 (46.0%) journals contained only 1 document, 48 (16.6%) journals contained 2, and 34 (11.8%) journals contained 3. The articles were included in 69 SCI subject categories. The top 10 subject categories with the most number of articles were marine & freshwater biology (868), oceanography (488), environmental sciences (398), ecology (372), limnology (101), multidisciplinary geosciences (86), fisheries (82), environmental engineering (67), microbiology (60), and water resources (56).

Table 1 lists the most productive journals on coastal eutrophication research with the number of papers, percentage of total documents, CPP, IF, ISI category of journals, and journal position in the category. The IF of a journal was determined for each document as reported in the year 2008 JCR. The Journal of *Limnology and Oceanography* had the highest average CPP (33.4) and the highest IF (3.663) among the 18 journals listed in Table 1, while the journal of *Estuaries (Estuaries and Coasts)* had the fourth highest average CPP (17.4), but had the sixteenth highest IF (1.408). Contrary to what was expected, the relationship between CPP and IF for articles published in coastal eutrophication was weak. Figure 3 shows the curves variation of CPP and IF of each journal. Both plots showed downtrend, while IF of each journal was evidently decreased. However, CPP of each journal was fluctuated significantly during the process of descending curve.

3.3 Country of publication

There were 5 articles (0.318%) without author address information. There were 1,565 articles with author address information, published from 1993 to 2002. This covered 82 countries/territories, of which 235 (15.0%) articles were international collaborations covering 69 countries/territories and 1,330 (85.0%) articles were independent publications covering 58 countries/territories. 24 (29.3%) countries had no independent and 13 (15.9%) countries had no collaborative publications. Table 2 lists the countries/territories published at least two articles a year on average. The USA contributed 35.0% of all articles, which was the most in all the countries/territories. The ten most independently productive countries/territories produced more than 70% of independent articles, including USA (35.4%), Sweden (5.19%), Australia (4.96%), UK (4.81%), Germany (4.44%), France (4.36%), the Netherlands (3.76%), Italy (3.61%), Japan (3.61%), and Denmark (3.31%).

Table 1 The 18 most active journals with journals information between 1993 and 2002

Journal	TP (%)	CPP (R)	IF	Subject category	Position
Marine Ecology-Progress Series	171 (10.9)	19.1 (3)	2.631	Ecology Marine & Freshwater Biology	40/124 11/87
Hydrobiologia	94 (5.99)	9.05 (16)	1.449	Oceanography	7/50
Estuaries (Estuaries and Coasts)	83 (5.29)	17.4 (4)	1.408	Marine & Freshwater Biology Environmental Sciences	36/87 83/163
Estuarine Coastal and Shelf Science	78 (4.97)	14.6 (9)	2.072	Marine & Freshwater Biology Marine & Freshwater Biology	37/87 19/87
Limnology and Oceanography	52 (3.31)	33.4 (1)	3.663	Oceanography Limnology	14/50 1/19
Journal of Experimental Marine Biology and Ecology	48 (3.06)	14.4 (10)	2.074	Oceanography Ecology	2/50 50/124
Marine Pollution Bulletin	46 (2.93)	14.2 (11)	2.562	Marine & Freshwater Biology Environmental Sciences	18/87 34/163
Journal of Plankton Research	30 (1.91)	12.3 (12)	1.707	Marine & Freshwater Biology Marine & Freshwater Biology	12/87 29/87
Marine Biology	29 (1.85)	16.5 (7)	1.953	Oceanography	20/50
Aquatic Microbial Ecology	25 (1.59)	17.2 (5)	2.19	Marine & Freshwater Biology Ecology	22/87 47/124
Journal of Marine Systems	23 (1.46)	12.2 (14)	2.255	Marine & Freshwater Biology Microbiology	17/87 46/91
Journal of Sea Research	20 (1.27)	16.2 (8)	2.065	Geosciences, Multidisciplinary Oceanography Marine & Freshwater Biology Oceanography	30/143 10/50 16/87 15/50
				Marine & Freshwater Biology	20/87

Table 1 continued

Journal	TP (%)	CPP (R)	IF	Subject category	Position
Canadian Journal of Fisheries and Aquatic Sciences	20 (1.27)	19.2 (2)	2.276	Fisheries	5/40
AMBIO	18 (1.15)	17.2 (5)	2.092	Marine & Freshwater Biology Environmental Sciences	15/87 50/163
Fresenius Environmental Bulletin	18 (1.15)	1.28 (18)	0.463	Engineering, Environmental	8/38
Ecological Modeling	17 (1.08)	11.4 (15)	2.176	Environmental Sciences	154/163
Environmental Monitoring And Assessment	17 (1.08)	5.41 (17)	1.035	Ecology	48/124
Continental Shelf Research	17 (1.08)	12.3 (12)	2.136	Environmental Sciences Oceanography	112/163 12/50

TP (%) Number of Publications and percentage of total publication for a certain journal, *CPP (R)* Citations per publication and the rank, *IF* Impact Factor (Determined by the 2008 edition of the Journal Citation Reports)

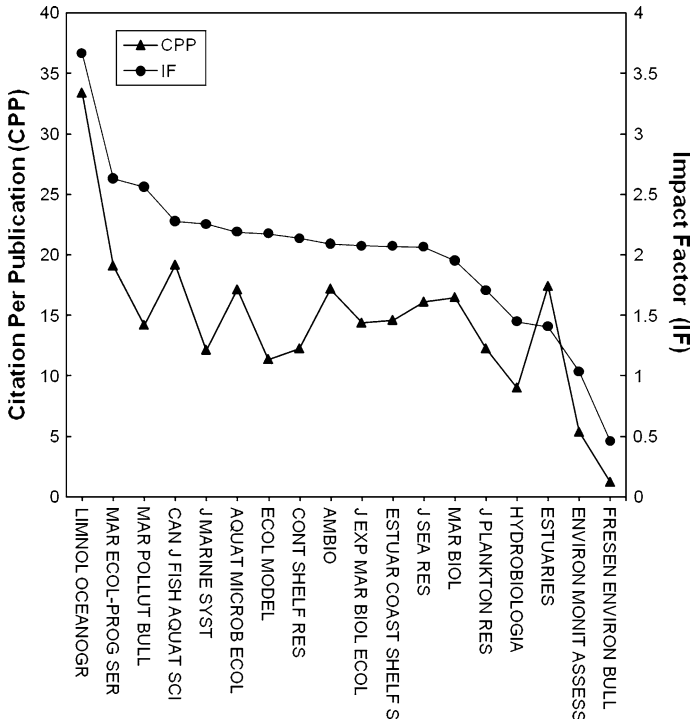


Fig. 3 The curves variation of CPP and IF of each journal

Denmark had the highest CPP_T (20.3) and CPP_S (20.5), while Sweden had the highest CPP_C (23.8). Moreover, for the countries had both independent and international collaboration publications, mean value of CPP_C (18.3) was higher than CPP_T (15.2), which means collaborative publications had higher impact in the research field. In addition, all countries/territories listed in Table 2 were located along the coast, which indicates that these countries/territories were easily suffered from the effects of eutrophication. Thus, they had paid more attention to the coastal eutrophication research.

3.4 Institute of publication

The total 1,565 articles with author address information published from 1993 to 2002 were analyzed. There were 999 institutes, 537 (53.8%) institutes had no independent articles, and 236 (23.6%) had no collaborative articles. 606 (38.7%) were inter-institutionally collaborative publications, and 959 (61.3%) were independent publications. The percentage of collaboration between institutes (38.7%) was higher than that between countries (15.0%). Table 3 lists the top 9 productive institutes published at least 20 articles during the period of 1993 to 2002. The institutes in USA occupied the majority of the top 9 productive institutes. University of Maryland in USA was the most productive for total articles, independent articles and inter-institutionally collaborative articles, but had the 8th CPP rank of total articles and the inter-institutionally collaborative articles. United States Geological Survey in USA had the highest CPP of independent articles, while University of North Carolina in USA had the highest CPP of total articles and the inter-institute

Table 2 Publication activity of countries from 1993 to 2002 and citation impact in the 6 years after publication year

Country/Territory	TP (%)	CPPT (R)	SP (%)	CPPS (R)	CP (%)	CPPC (R)
USA	549 (35.0)	20.1 (2)	471 (35.4)	20.0 (2)	78 (33.2)	21.0 (2)
Sweden	105 (6.69)	16.7 (3)	69 (5.19)	12.9 (6)	36 (15.3)	23.8 (1)
Australia	82 (5.22)	11.5 (13)	66 (4.96)	10.4 (14)	16 (6.81)	16.1 (12)
UK	95 (6.05)	13.9 (9)	64 (4.81)	12.7 (8)	31 (13.2)	16.5 (11)
Germany	103 (6.56)	15.2 (5)	59 (4.44)	13.7 (5)	44 (18.7)	17.1 (9)
France	94 (5.99)	13.4 (10)	58 (4.36)	10.9 (12)	36 (15.3)	17.4 (8)
The Netherlands	73 (4.65)	16.2 (4)	50 (3.76)	16.1 (3)	23 (9.79)	16.5 (10)
Italy	62 (3.95)	13.0 (12)	48 (3.61)	12.7 (9)	14 (5.96)	14.3 (14)
Japan	53 (3.38)	9.23 (15)	48 (3.61)	8.35 (16)	5 (2.13)	17.6 (6)
Denmark	73 (4.65)	20.3 (1)	44 (3.31)	20.5 (1)	29 (12.3)	20.0 (4)
Finland	67 (4.27)	13.1 (11)	43 (3.23)	12.0 (10)	24 (10.2)	15.2 (13)
Spain	54 (3.44)	14.8 (8)	42 (3.16)	14.1 (4)	12 (5.11)	17.5 (7)
Canada	60 (3.82)	15.1 (6)	39 (2.93)	12.7 (7)	21 (8.94)	19.5 (5)
Greece	37 (2.36)	5.54 (18)	33 (2.48)	4.58 (18)	4 (1.70)	13.5 (15)
China	27 (1.72)	9.19 (16)	23 (1.73)	9.30 (15)	4 (1.70)	8.50 (17)
Brazil	24 (1.53)	6.88 (17)	16 (1.20)	5.38 (17)	8 (3.40)	9.88 (16)
Norway	26 (1.66)	14.9 (7)	16 (1.20)	11.3 (11)	10 (4.26)	20.7 (3)
Croatia	17 (1.08)	10.0 (14)	13 (0.980)	10.6 (13)	4 (1.70)	8.00 (18)

TP Total country publications, *CPPT* Citation per publication of total country publication, *SP* Single country publications, *CPPS* Citation per publication of single country publication, *CP* International collaboration publications, *CPPC* Citation per publication of international collaborative publication, *R* Rank

Table 3 The top 9 productive institutes from 1993 to 2002 and citation impact in the 6 years after publication year

Institute (Country)	TP (%)	CPPT (R)	SP (%)	CPPS (R)	CP (%)	CPPC (R)
University of Maryland, USA	39 (2.49)	19.7 (8)	22 (2.29)	21.2 (3)	17 (2.81)	17.8 (8)
Louisiana State University, USA	33 (2.11)	22.0 (7)	14 (1.46)	15.4 (9)	19 (3.14)	26.8 (3)
University of North Carolina, USA	27 (1.73)	34.0 (1)	15 (1.56)	28.4 (2)	12 (1.98)	41.0 (1)
National Environmental Research Institute, Denmark	23 (1.47)	23.0 (4)	9 (0.938)	19.6 (5)	14 (2.31)	25.3 (5)
United States Geological Survey, USA	22 (1.41)	24.3 (3)	5 (0.521)	19.2 (6)	17 (2.81)	25.8 (4)
University of Rhode Island, USA	21 (1.34)	27.4 (2)	7 (0.730)	37.4 (1)	14 (2.31)	22.4 (7)
United States Environmental Protection Agency, USA	21 (1.34)	14.2 (10)	14 (1.46)	17.1 (8)	7 (1.16)	8.57 (10)
National Oceanic & Atmospheric Administration, USA	21 (1.34)	22.9 (5)	7 (0.73)	10 (10)	14 (2.31)	29.4 (2)
College William & Mary, USA	20 (1.28)	16.6 (9)	12 (1.25)	18 (7)	8 (1.32)	14.4 (9)

TP Total institute publications, *CPPT* Citation per publication of total institute publication, *SP* Single institute publications, *CPPS* Citation per publication of single institute publication, *CP* Inter-institute collaboration publications, *CPPC* Citation per publication of inter-institute collaborative publication, *R* Rank

collaboration articles. The mean CPP of collaborative papers (24.6) was higher than that of single institute publications (20.6). This indicated that collaboration is the main development of trend in research and collaboration can get a higher impact in the research field.

3.5 Authorship

Figure 4 shows the distribution of articles and citation per publication by number of authors. There were 3,634 authors contributed to a total of 1,570 articles with the author name information between 1993 and 2002. The average authors per document were 2.31 with CPP of 15.1. Figure 4 shows the distribution of articles and citation per publication by number of authors. The value of CPP was varied with the number of authors. Among the 1,570 articles, 190 (12.1%) articles were consisted of one author. The most frequent number of authors was 1 to 4 (81.8% in total). Table 4 shows the most productive authors contributed at least ten articles, with the number of their total published articles, first author articles and corresponding author articles, and the CPP for the three kinds of articles. Turner, R. E. from Louisiana State University in USA was the most productive authors with 18 articles. Rabalais, N. N. from Louisiana State University in USA had the highest CPP for articles as corresponding author (67.5), the articles as first author (67.5), and total articles (37.1). A bias would appear in authorship analysis if any two or more authors have the same name, or authors used different names in their publications (e.g., name changes due to marriage) (Chiu and Ho 2007). In addition, authors may work for different institutions or countries over time or within a same period of time (e.g., Lotze, H. K., listed in Table 4), which would increase the difficulties in analyzing the authorship.

Therefore, it is strongly recommended to create an “international identity number (IIN),” which is offered to individual person for all authors when they published their first

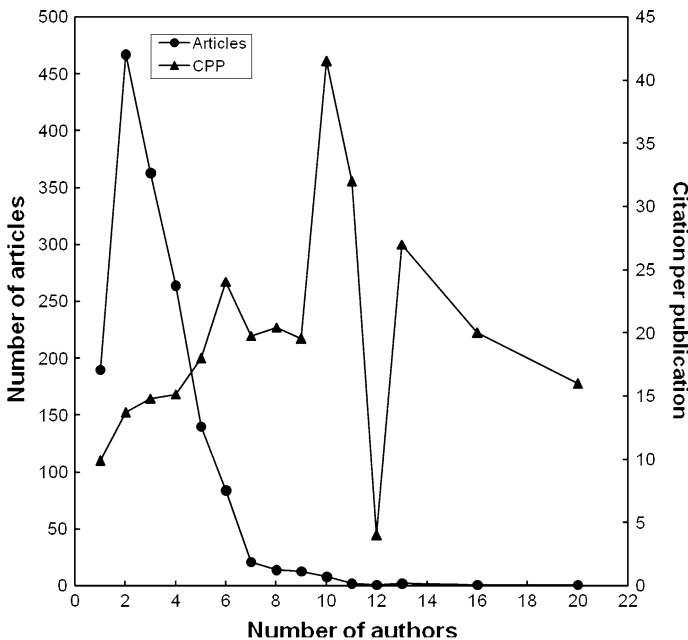


Fig. 4 The distribution of articles and citation per publication by number of authors

Table 4 The most productive authors contributed at least ten articles between 1993 and 2002

Author	Institute/country	TP (%)	CPPT (R)	FA (%)	CPPF (R)	RP (%)	CPPR (R)
Turner, RE	Louisiana State University, USA	18 (1.00)	35.8 (3)	4 (0.221)	31.8 (4)	4 (0.221)	31.8 (3)
Valiela, I	Boston University, USA	18 (1.00)	31.4 (4)	6 (0.332)	34.7 (3)	8 (0.443)	28.1 (4)
Paerl, HW	University N Carolina, USA	16 (0.890)	29.6 (6)	5 (0.277)	44.2 (2)	5 (0.277)	44.2 (2)
Rabalais, NN	Louisiana State University, USA	16 (0.890)	37.1 (1)	4 (0.221)	67.5 (1)	4 (0.221)	67.5 (1)
Karydis, M	University of the Aegean, Greece	14 (0.775)	6.14 (9)	3 (0.166)	7.00 (8)	3 (0.166)	7.00 (8)
Dortch, Q	Louisiana Universities Marine Consortium, USA	10 (0.553)	36.1 (2)	2 (0.111)	12.0 (7)	2 (0.111)	12.0 (7)
Lotze, HK	Dalhousie University, Canada Institute für Meereskunde, Germany	10 (0.553)	30.3 (5)	6 (0.332)	26.0 (5)	6 (0.332)	26.0 (5)
Nedwell, DB	University Essex, England	10 (0.553)	21.1 (7)	3 (0.166)	25.0 (6)	4 (0.221)	22.0 (6)

TP One author's total publications, CPPT Citation per publication of one author's total publications, FA One author's publications as the first author, CPPF Citation per publication of one author's publications as the first author, RP One author's publications as the corresponding author, CPPR Citation per publication of one author's publications as the corresponding author, R Rank

paper in the ISI-listed journal. We believe it will be an appropriate way to accurately record the authorship by assigning and tracing IIN.

3.6 Author keywords analysis

The frequency change of author keywords indicates the formation and shift of hot research. By analyzing the author keywords will help to track the research trend. In this study, the author keywords for a total of 2,589 articles with records that included keywords in the SCI database between 1993 and 2008 were undertaken. The results of the author keywords analysis shows that a total 6,530 keywords were listed, with the synonymous keywords, or single and plural keywords integrated together. 4,913 (75.2%) keywords were used only once, 729 (11.2%) keywords were used twice, and 284 (4.35%) keywords were used three times. Table 5 gives a list of high frequency keywords, which appeared more than 20 times. The results also reveal that the coastal eutrophication research mainly focus on the definition, forces, effects, assessment methods & indicators and diagnostic tools, etc.

Table 5 Keywords citing rank and percentage of publication in different period

Author keywords	1993–1996 rank (%)	1997–2000 rank (%)	2001–2004 rank (%)	2005–2008 rank (%)
Eutrophication	1 (27.0)	1 (30.0)	1 (26.4)	1 (24.9)
Nutrients	2 (12.8)	2 (11.0)	2 (11.6)	2 (11.4)
Hypoxia	7 (5.75)	5 (7.55)	4 (9.13)	3 (8.48)
Estuary	3 (9.73)	4 (8.24)	3 (9.82)	4 (6.82)
Nitrogen	5 (8.41)	5 (7.55)	5 (7.88)	5 (6.57)
Phytoplankton	6 (6.64)	3 (8.92)	6 (7.75)	6 (5.90)
Phosphorus	4 (9.29)	7 (5.49)	7 (6.09)	7 (5.32)
Water quality	20 (2.21)	13 (2.75)	8 (4.43)	8 (4.49)
Chlorophyll A	17 (2.65)	37 (1.37)	11 (3.46)	9 (3.91)
Baltic sea	9 (4.87)	7 (5.49)	10 (4.01)	10 (3.82)
Sediment	10 (4.42)	10 (3.43)	9 (4.15)	10 (3.82)
Seagrass	10 (4.42)	15 (2.52)	13 (2.49)	12 (3.08)
Stable isotopes	NA	47 (1.14)	47 (0.97)	13 (2.66)
Macroalgae	25 (1.77)	15 (2.52)	12 (3.32)	14 (2.58)
Salinity	142 (0.440)	15 (2.52)	26 (1.52)	15 (2.41)
Diatoms	20 (2.21)	23 (1.83)	18 (2.07)	15 (2.41)
Dissolved oxygen	142 (0.440)	23 (1.83)	17 (2.21)	17 (2.24)
Nutrient enrichment	20 (2.21)	23 (1.83)	13 (2.49)	18 (2.16)
Harmful algal blooms	NA	266 (0.230)	29 (1.38)	18 (2.16)
Coastal lagoon	8 (5.31)	47 (1.14)	13 (2.49)	20 (1.91)
Zooplankton	25 (1.77)	37 (1.37)	18 (2.07)	21 (1.66)
Primary production	12 (3.98)	9 (4.35)	32 (1.24)	21 (1.66)
Chesapeake bay	41 (1.33)	23 (1.83)	26 (1.52)	21 (1.66)
Climate change	NA	37 (1.37)	240 (0.280)	21 (1.66)

NA not applicable

Nutrient enrichment induced by human activities was the primary force to coastal eutrophication, it obtained stable concern during the study period. Moreover, climate change in combination with human induced coastal eutrophication via nutrients loading can lead to adverse consequences for ecosystem functioning and services. Evidences show that climate induced oligotrophication in the absence of any significant reduction in nutrient concentrations or inputs in Narragansett Bay (Fulweiler and Nixon 2009), “climate change” study was getting more concerned in recent year, which ranked 21st in 2005–2008, while it had no appearance in 1993–1996. Hypoxia is a common effect of eutrophication in bottom waters and is becoming an increasingly prevalent worldwide problem (Conley et al. 2009). Its significance can be noticed from the author keywords’ rank shift. “Hypoxia” study ranked 7th in 1993–1996 and top 3rd in 2005–2008. Eutrophication-related harmful algal blooms are growing in frequency, geographic extent and duration throughout the world (Glibert 2007), “harmful algal blooms” study had the rapid development, which had no occurrence in 1993–1996, ranked 266th in 1997–2000, ranked 29th 2001–2004, and ranked 18th in 2005–2008. Traditional coastal eutrophication monitoring method mainly is physico-chemical method. However, the monitoring method does not always functioned properly. New techniques, such as stable isotopes and remote sensing, were applied in coastal eutrophication monitoring (Cohen and Fong 2005; Focardi et al. 2006), which both had no appearances in 1993–1996, ranked 47th and 62nd in 1997–2000, ranked 47th and 39th in 2001–2004, and ranked 13th and 54th in 2005–2008.

4 Conclusions

The scientometric study on coastal eutrophication based on Science Citation Index database from 1993 to 2008 shows that USA is the most productive country in this field. The ten developed countries produced 80% of independent articles, including USA, Sweden, Australia, UK, Germany, France, the Netherlands, Italy, Japan, and Demark. This reflects the effect of economic factor in some degree. The institutes in USA occupied the majority of the top 10 productive institutes. University of Maryland in USA was the most productive for total articles and independent articles. Louisiana State University in USA was the most productive for inter-institutionally collaborative articles. The most frequent number of authors was 1–4.

The study also indicated that the indicator of CPP provided an effective way to assess impact of a publication. Collaboration trend was toward multi-authors, multi-institutes, and multi-countries papers. It was consistent with the research trends of coastal eutrophication. Coastal eutrophication is not a process affecting individual ecosystems, but is a global phenomenon both in its global spread and in the relative synchrony of this spread. It is necessary to promote major internationally collaborative programs to investigate global change of coastal eutrophication.

Keywords analysis successfully gave interesting insights into the dynamics of this field. The study showed that coastal eutrophication research mainly focus on the definition, forces, effects, assessment methods & indicators and diagnostic tools. These were the hottest topics throughout the study periods. Harmful algal blooms and hypoxia both had the rapid development from 1993 to 2008. Stable isotopes and remote sensing as new techniques to monitor coastal eutrophication were used more frequently. The force like climate change that shape coastal eutrophication was getting more concerned in recent year.

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