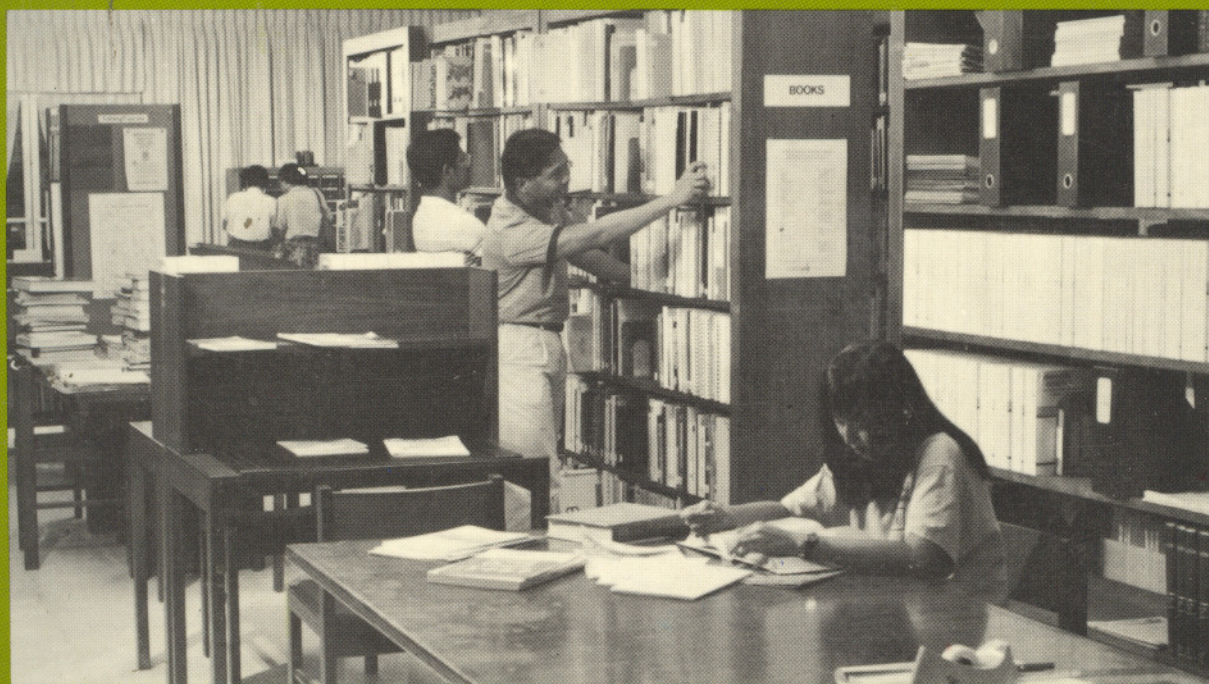


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Bibliographic Impact of ICLARM

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International Center for Living Aquatic
Resources Management

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Cover: ICLARM's library. Newer books, journals and reports on the shelves contain more and more references to ICLARM's work. Photo by Ramon Estarez.

ICLARM Contribution No. 584.

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Bibliographic Impact of ICLARM

Abstract

A study was made of the availability and impact of the publications and other contributions to the literature of the International Center for Living Aquatic Resources Management (ICLARM), based in the Philippines. The availability of ICLARM items in several commercial databases was ascertained and manual citation counts were made from the Center's library material and staff personal reprint collections.

Over 300 citations of ICLARM items annually were found for recent years, with a total of 2,131 citations from 1979 to February 1988. The proportion that these items make in reference lists of articles in which they are cited has been increasing over time. Two-thirds of the citations were from developing-country based authors. Fifty-three per cent of all the Center's technical contributions had been cited during the period covered, distributed over 52 countries. Some items had very high counts, e.g., 285 citations of a conference proceedings volume; 152 citations of a journal article.

A close relationship was found between numbers of copies of ICLARM's Conference Proceedings series distributed and citations ($r = 0.93$), with less clear relationships for other series.

It was concluded that the Center had made a substantial impact in fisheries research literature. ICLARM's mode of publication was concluded to be successful, although improvement was possible by publishing more results in the primary literature.

Introduction

The major target audience of ICLARM since its inception has been the fisheries research community in tropical developing countries "with a view", as stated in the ICLARM Articles of Incorporation 1977, "to assisting the peoples of the world in rationally developing their aquatic resources to meet their nutritive and economic needs." ICLARM is a nonprofit international research center and is externally funded. As such it must answer to donors on the usefulness of the efforts of Center personnel in achieving this aim.

The Center's most visible outputs are its publications. At ICLARM's inception, it was decided to "publish and disseminate research findings and recommendations of the Center." Thus, most of ICLARM's work has appeared under the ICLARM Logo in its various series: *Conference Proceedings (from 1979)*, *Studies and Reviews (1979)*, *Technical Reports (1981)*, *Bibliographies (1980)*, *Translations (1980)*, *Education (1987)* and *Software (1987)*. Most are copublished with the research or cooperative partners involved. Some authors are nonICLARM scientists.

ICLARM authors also contribute to technical and other reports of other organizations, particularly FAO, while further contributions appear in the primary literature, in external conference proceedings, and in semitechnical publications, mainly *Naga* the ICLARM quarterly and its predecessor the ICLARM Newsletter, and *Fishbyte*, the newsletter of the Network of Tropical Fisheries Scientists. By the end of 1987 the total numbers of ICLARM contributions in these categories were as shown in Table 1.

Table 1. Distribution of ICLARM contributions to the literature since 1977, by publication type. All but 20 of these contributions date from 1980 to 1987.

Primary literature	
Journal articles	36
ICLARM Studies and Reviews	15
Conference proceedings, papers and book chapters	110
Report literature	
technical reports	58
bibliographies	7
translations	8
other report literature	21
Semitechnical literature	123
TOTAL	378

ICLARM's headquarters are in Manila, Philippines, not an ideal site from which to base a global literature distribution system. A "sister" organization, the International Rice Research Institute, also situated in the Philippines, found that an estimated 30% of its outgoing surface mail disappears *en route* (T. Hargrove, pers. comm.). In 1984, ICLARM began appointing distributors to overcome this problem, one in the USA and later a second in Europe. (A large shipment of books was received by a third company, Pioneer Publishers and Distributors, Bombay, India, but nothing was heard of either books or company again.)

It was decided to investigate the impact of the Center's publications and other contributions to the literature by determining their availability in major databases and to what degree they have been cited by others. This would represent a minimum picture of usefulness, since not all those who read and derive information from a book/article would subsequently cite it. The study was carried out to learn also whether there was a relationship between the number of copies of a publication disseminated and its citation rate.

Methods

For the purpose of investigating the bibliographic impact of ICLARM, a count was made of references in the literature to bibliographic items attributable to ICLARM, referred to in the remainder of this text as ICLARM items. These include:

1. The ICLARM Contribution Series, noted above, of 378 items by ICLARM authors and by nonICLARM authors of ICLARM publications as shown in Table 1. These are referred to below as Contributions.
2. Items by nonICLARM authors in ICLARM-edited publications, such as conference proceedings, some technical reports and newsletter articles. These amount to approximately 400 items, although about 75% are semitechnical material. Such items are referred to below as noncontributions.

The survey was made in February 1988 and was based solely on material available in ICLARM's library and staff personal collections. Library staff had also been scanning various incoming material for citations of ICLARM since 1984. Data were entered into a dBase type database on a microcomputer for analysis.

Searches were also made of several commercial computer databases to determine the extent of their coverage of ICLARM items. A search of the USA-based Institute for Scientific Information's (ISI) databases Scisearch and Social Scisearch was made to locate both ICLARM items and citations of them.

Citing sources were identified by (senior) author, year, type of publication, number of references to ICLARM, total number of references and country of publication. Citing source material was classified into primary, report and semitechnical literature plus conference/book items as for ICLARM contributions (Table 1), to which was added a category for theses and dissertations. Where one or more citations to ICLARM were found, all references in that list were counted to determine the proportion of ICLARM material in the referenced literature.

In the following account, the *cited* documents/items are the ICLARM items categorized above, and the *citing* documents are the various journal articles, conference papers, etc., which cite the ICLARM items.

ICLARM Items in Computer Databases

AGRIASIA, an abstract database from the Agricultural Information Bank for Asia, held a total of 4,987 bibliographic entries on fisheries and aquaculture from 1974 to the end of 1987. ICLARM items totalled 144.

Scisearch covered about 3,300 major journals in 1987, most of which were European and North American. Bibliographic holdings date from 1974. The number of items attributable to ICLARM authors to end 1987 was 40. Only two of the 40 items were found in Social Scisearch and not also in Scisearch. Of the 40, 33 were true primary literature (journal articles). The other seven were conference summaries published in the news section of some primary journals. Thus 90% of ICLARM's 36 primary journal articles were covered by ISI databases.

ASFA, the Aquatic Sciences and Fisheries Abstracts database from FAO, holds entries from 1978. It increases by about 20,000 entries per year (in the living resources section). The 1982-July 1987 period was searched on the compact disc version of ASFA. The number of ICLARM items was 285 (out of approximately 116,000 items).

Citations

The total number of citations to ICLARM items found was 2,131. Of these, 202 or 9.4% were included in Scisearch/Social Scisearch. (Citation data are provided in ISI's Science Citation Index (SCI)). The total number of citing items was 901, giving an average of 2.4 citations per cited item. However, the range, 0-285, was quite broad.

Citations in Relation to Citing Documents

The characteristics of the documents which cite ICLARM items are shown in Table 2. The major type of citing item was the technical report literature. Primary literature and conference papers were of approximately equal ranking in second place. Nearly 11% of all the citations were in theses - not strictly publications but an indication of the impact of the Center's publications in higher education.

Primary literature comprised about one-fifth of all citing document types. The major citing journal was *Aquaculture* with 68 citations. Appendix 1 shows the top ten citing journals, as well as citations in some prominent proceedings and in the publications of various institutions.

The proportions that ICLARM items make of the total references in documents that cite ICLARM are also shown in Table 2. Leaving aside the minor semitechnical and "other" report literature, ICLARM items were most prominent in the conference paper, thesis and technical report literature. The average proportion of ICLARM material in reference lists citing ICLARM for all document types was 5.1%.

The temporal pattern of proportionality in Table 3 shows that the proportion of ICLARM items in the reference lists of most citing categories has been increasing over time.

The data, smoothed by running three-year averages in Fig. 1, show that technical reports have shown the most rapid "adoption" of ICLARM material, with proportions of ICLARM references rising from 4% in 1982 to 15% in 1987. Book chapters showed the least increase. The average increase, shown in Fig. 1b, suggests a linear increase of about 0.8%/year in the proportion of ICLARM items in reference lists over the period.

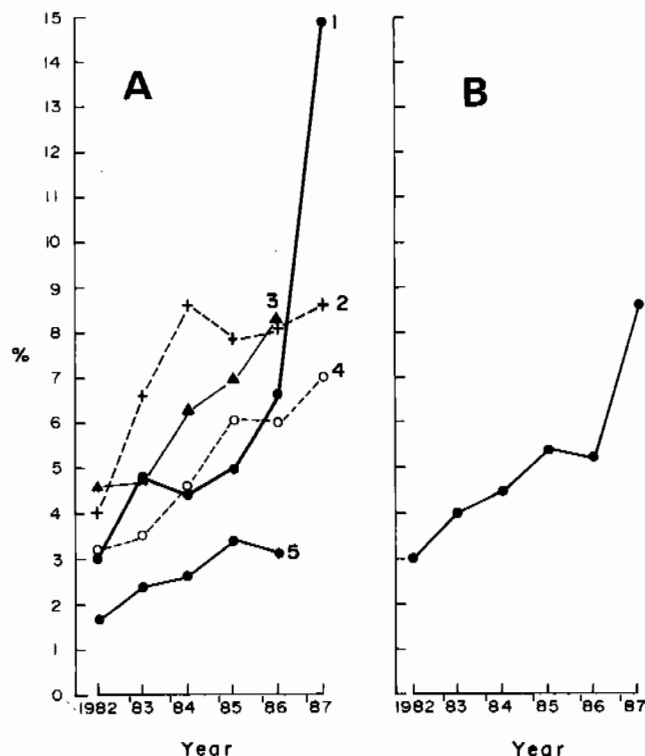


Fig. 1. Proportion of ICLARM citations in reference lists of articles that cite at least one ICLARM item, over time. A. By citing document type: 1 = technical reports; 2 = conference papers; 3 = theses; 4 = primary literature; 5 = books/chapters. B. All citing types combined. Points are 3-year running averages from data in Table 3.

This proportionality or "visibility" measure may express the relative increase in influence over time of ICLARM items in each discipline or document type. Table 3 shows that ICLARM's influence is increasing (by this measure) over time. However, no comparable data are available to test this hypothesis.

Table 2. Characteristics of documents citing ICLARM items. N = 2,131.

Document type	Proportion of all citing documents (%)	Ave. proportion of ICLARM items in all citations (%)
Primary literature	22.1	4.7
Conference papers	22.9	7.2
Book chapters	14.1	3.2
Technical reports	28.2	6.3
Other reports	1.7	8.1
Semitechnical	0.2	10.4
Theses/dissertations	10.8	6.6
Average		5.1

Table 3. Temporal patterns in the average proportion (%) of ICLARM citations of all citations in reference lists citing ICLARM items (semitechnical literature omitted except in all items combined). N = total number of references in citing items.

	1981	1982	1983	1984	1985	1986	1987	1988
Primary literature (N = 10,800)	4.5	2.6	2.6	5.2	6.1	6.9	5.1	9.1
Conference papers (N = 6,782)	1.2	2.7	8.0	9.0	7.7	7.1	9.5	9.1
Book Chapters (N = 11,278)	1.8	1.4	1.8	3.9	2.3	3.9	3.0	-
Technical reports (N = 9,795)	2.1	4.6	3.1	6.7	3.3	5.1	11.5	28.1
Theses/dissertations (N = 3,296)	6.7	4.8	2.4	7.1	9.3	4.6	11.1	-
All items combined (N = 42,478)	2.8	3.1	3.0	6.0	4.6	5.6	5.3	15.0

Growth of the citations overall and according to citing document type over time is depicted in Fig. 2. Most citation activity at present is in the report literature. The temporal patterns are broadly similar for each citing document type, suggesting roughly equal use of ICLARM publications amongst the various types of citing literature.

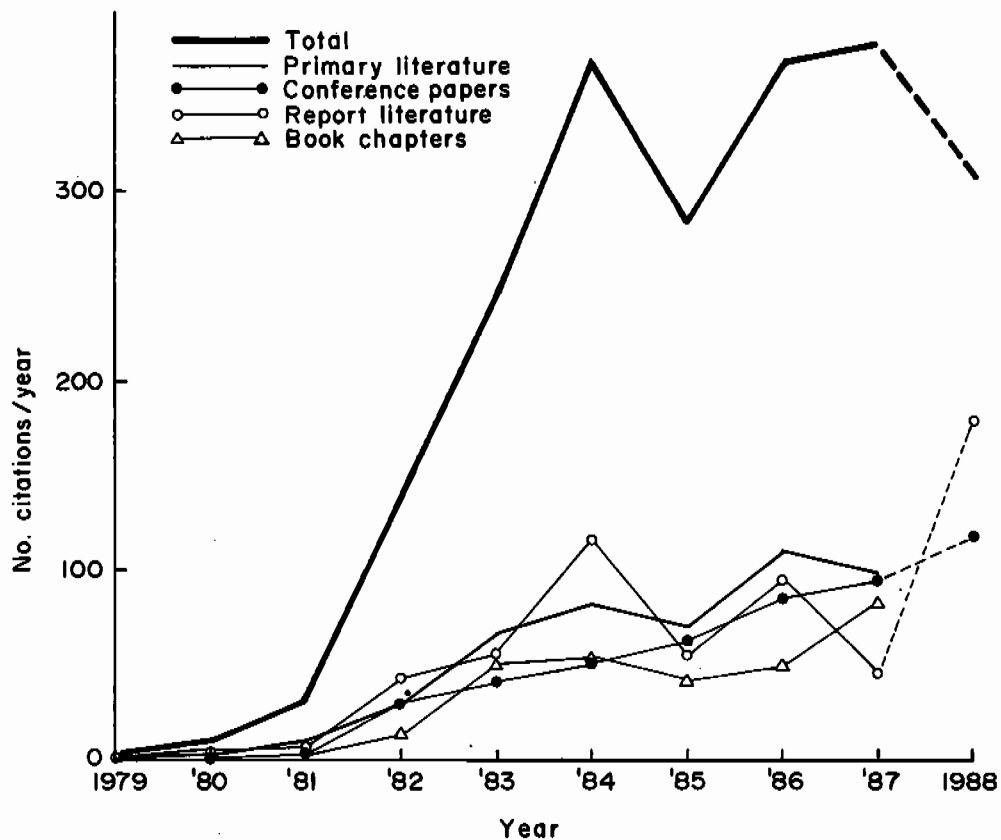


Fig. 2. Citations of ICLARM items per year according to citing document type. Data for 1988 are up to February only.

The geographic spread of documents citing ICLARM was measured by the countries in which they are published. ICLARM material was cited in publications from 52 countries. These data are shown on a regional basis in Table 4. The complete country list is given in Appendix 2.

Table 4. Geographical (regional) distribution of citations to ICLARM items by type of citing item^a

Document Type	Region									FAO	ICLARM ^b	TOTAL
	1	2	3	4	5	6	7	8	9			
Journal articles	143	12	9	5	7	21	24	239	10	0	0	470
Conference papers	72	2	2	52	12	0	86	37	25	1	198	487
Book chapters	114	16	0	0	0	0	26	128	9	3	4	300
Technical reports	24	10	9	24	15	1	100	20	41	358	0	602
Other reports	0	4	2	3	0	0	9	6	6	6	0	36
Semitechnical	0	0	0	0	0	0	4	0	1	0	0	5
Theses	39	4	0	0	0	4	114	70	0	0	0	231
Totals	392	48	22	84	34	26	363	500	92	368	202	2,131

^aRegions: 1 = North America; 2 = South America; 3 = Africa; 4 = Middle East; 5 = South Asia; 6 = East Asia; 7 = Southeast Asia; 8 = Europe; 9 = Oceania.

^bExcludes documents by ICLARM staff, i.e., excludes ICLARM Contributions

Europe was the origin of the largest group of citations. The major countries were the UK, the Netherlands and the Federal Republic of Germany. Details are given in Appendix 2. The Netherlands is the site of much journal publishing: 85% of Dutch citations were in journal articles, while only 43% were in journal articles in the UK. In North America, the proportion of citations in the primary literature was even less - 28% in the USA.

Note that European journals are not exclusively for European authors. *Aquaculture*, a journal from the Netherlands, was the source of 68 citations to ICLARM items. The countries of origin of the citing authors were not determined during the present survey. However, the regional distribution of authors of articles in *Aquaculture* volumes 59 and 60 (1986, 1987), shown in Table 5, shows that "western" authors (from North America and Europe) were, in fact, prominent, although only 35% were from Europe and only 3 were from the Netherlands.

Table 5. Regional distribution of countries of authors in *Aquaculture*. Vols. 59, 60 (1986, 1987). N = 138.

Region	Proportion(%)
North America	30
South America	6
Middle East	16
East Asia	3
Southeast Asia	10
Europe	35

This example indicates that the regional distribution of citations in Table 4 does not reflect authors' nationalities. Rather it is biased towards the countries of origin of major journals. If the example in Table 5 is representative of European journal publishing, then rather more citations came from persons in the USA and developing countries. The European citations may be roughly divided equally between Europe, North America and developing countries. Citations from USA are undoubtedly mainly "indigenous", but there is some "leakage" since European and developing-country authors do publish in US-based publications.

Outside the western countries, Southeast Asia is the largest source of citations, the Philippines being the main "audience" (287 citations). Interestingly, of the Philippine citations, 114 were in theses, much higher than the global average and indicating the Center's impact in that country's higher education programs in fisheries.

FAO is the largest "point" source of citations; the various FAO report series account for nearly 60% of all the report literature citing ICLARM items.

Overall, Table 4 shows that 42% of citations came from developed countries of Europe and North America. A reallocation of European citations based on country of authorship rather than of publication using the above estimates and adding citations from Japan and Australia, would indicate that only 36% of all citations were from developed-country based authors. A probably small but underdetermined percentage of developed-country authors publishing in developing-country publications could not be taken into account. However, a division of citations into one-third developed-country and two-thirds developing-country based authors would be a reasonable assessment.

The data shown in Tables 2 and 3 are for all ICLARM items. These data are further divided into citations of ICLARM Contributions and noncontributions in Table 6. Citations of ICLARM Contributions comprised about 71%; noncontributions the remaining 29%.

Table 6. Distribution of citations of ICLARM items according to cited document type.

Cited Document Type	No. Citations
ICLARM Contributions	
Primary literature	
Studies and Reviews	261
Journal articles	303
Conference proceedings/papers	293
Book chapters	9
Technical Reports	393
Translations	3
Bibliographies	17
Other report literature	22
Semitechnical	207
Sub total	1,508 (71%)
Noncontributions	
Primary literature	
Studies & Reviews	3
Journal articles	0
Conference papers	483
Technical Reports	6
Other report literature	3
Semitechnical	127
Sub total	622 (29%)
TOTALS	2,130

Citations in Relation to Cited Documents

The total number of ICLARM items cited was 256, of which 184 were ICLARM Contributions.

The distribution of all citations according to type of cited document is shown in Table 6. Technical reports were the most often cited Contributions, with conference papers, journal articles and ICLARM Studies and Reviews roughly equal in second place. Most cited noncontributions (articles by nonICLARM persons in ICLARM publications) were papers in the ICLARM Conference Proceedings series and semitechnical articles, such as in Naga and Fishbyte.

In Table 7 below are the numbers of ICLARM Contributions cited, compared with the numbers published by end 1987.

Table 7. Proportion of cited ICLARM Contributions by document type.

ICLARM Contribution	Published	Cited	% Cited
Primary literature			
Journal articles	36	17	47
Studies & Reviews	15	13	87
Conference papers, proceedings and book chapters	110	52	47
Report literature			
Technical reports	58	39	67
Bibliographies	7	5	71
Translations	8	3	37
Other reports	21	6	29
Semitechnical literature	123	47	38

The average citation age - the difference in years between publishing and citation dates - according to the various citing document types is shown in Table 8.

Table 8. Average age in years of citations of ICLARM items

1.	Cited Documents (ICLARM items)	
	Primary literature	
	Journal articles	4.5
	Studies and Reviews	3.6
	Book chapters	2.0
	Conference papers	3.6
	Technical reports	3.2
	Translations	5.5
	Bibliographies	3.0
	Other reports	3.4
	Semitechnical	3.0
2.	Citing Documents	
	Journal articles	3.6
	Conference papers	3.9
	Book chapters	3.7
	Technical Reports	3.4
	Other reports	2.7
	Theses	3.0
3.	Average citation age	3.5

Note that the citations of ICLARM's journal articles (Table 7) conform to the often-quoted statistic that about half the primary literature is never cited (at least over the time period covered in this study). It is also of interest that the proportion cited (47%) was the same for conference papers, etc. (Table 7). More of ICLARM's Technical Reports received citations while nearly all the Studies and Reviews have been cited. (Actual numbers of citations showed a different pattern of course (Table 6)).

The average age of citations according to cited document type (Table 8) shows a range of 2.0 - 5.5 years. For the most cited types of ICLARM items, book chapters, Studies and Reviews and Technical Reports, citation ages are close to the average of 3.5 years while journal articles are on average older (4.5 years) when cited. With regard to the citing documents, the major citing types are all fairly close to the average.

The older citation age of ICLARM's journal articles might be of concern if they were the major items cited. As shown elsewhere, however, they comprise only about 14% of all citations.

Given the average time lag of 3.5 years between publishing and citing, the "effective" number of Contributions published is somewhat lower than suggested in Table 7, and the proportions here of ICLARM items cited to date are, thus, conservative.

The average number of citations of the first 8 titles in the Studies and Reviews series (1979-1984) was 31. Only about half of the articles by ICLARM authors in primary journals have been cited, but of those some are very well cited, such as two articles by Daniel Pauly, with 152 and 80 citations, respectively. The average number of citations of the Center's 17 cited journal articles was 18. Of the 303 citations, 67% were in the SCI database.

Similarly, only half of the conference papers produced by staff have been cited. Those in the ICLARM series, edited by ICLARM staff, have in general been well cited. Of the eight major proceedings (1979-1985), the average number of citations was 76. ICLARM Technical Reports have not been cited extensively. For the first thirteen reports in the series, average citation rate was 12. On the other hand, a technical report by Daniel Pauly in the FAO Fisheries Circular series has received 99 citations. Details are included in Appendix 3.

ICLARM's bibliographies have been little cited, but these are bibliographic tools not expected to be cited. The translations are also poorly cited. These are prepared for particular purposes and are not distributed widely. Nearly all are produced by photocopying and usually less than 500 copies of each have been made; the lowest being 25 copies; the highest (the exception), 1,000 copies.

Finally, nearly 40% of the semitechnical articles have been cited. None have received high citations and, of course, such unreferenced and unrefereed articles are not intended for or suitable for general citation. In that respect, the fact that 47 of 123 semitechnical Contributions have been cited is a pleasant surprise. An account of the citations of Naga articles is given in Maclean (1988). Highly technical articles do appear in the newsletter Fishbyte and it will be interesting to follow their citations in the future.

Some items, especially edited Conference Proceedings, while receiving few citations as an entity, were well cited when the individual Contributions and noncontributions were taken into account. Foremost amongst these is *The Biology and Culture of Tilapias*, edited by R.S.V. Pullin (ICLARM) and R. Lowe-McConnell, 1982. This is a Conference Proceedings composed of a number of invited international review papers (as well as the discussions that followed delivery of each paper). For the proceedings volume, there were 31 citations. However, when citations to individual papers were added, the total number of citations to the publication was 285. These papers were well cited in Scisearch also; up to 100 citations were found in the primary literature. Details of the citations for each paper are given in Appendix 4.

Other ICLARM Conference Proceedings were also well cited when the citations to individual papers were summed. Details are provided in Appendix 3.

Relationship Between Citations and Number of ICLARM Publications Distributed

Of interest are the patterns of citation versus number of publications distributed (Fig. 3). For the Conference Proceedings series there was a highly significant positive relationship ($r=0.93$), while for Studies and Reviews and Technical Reports, no such relationship is apparent, with r values of 0.44 and 0.30, respectively.

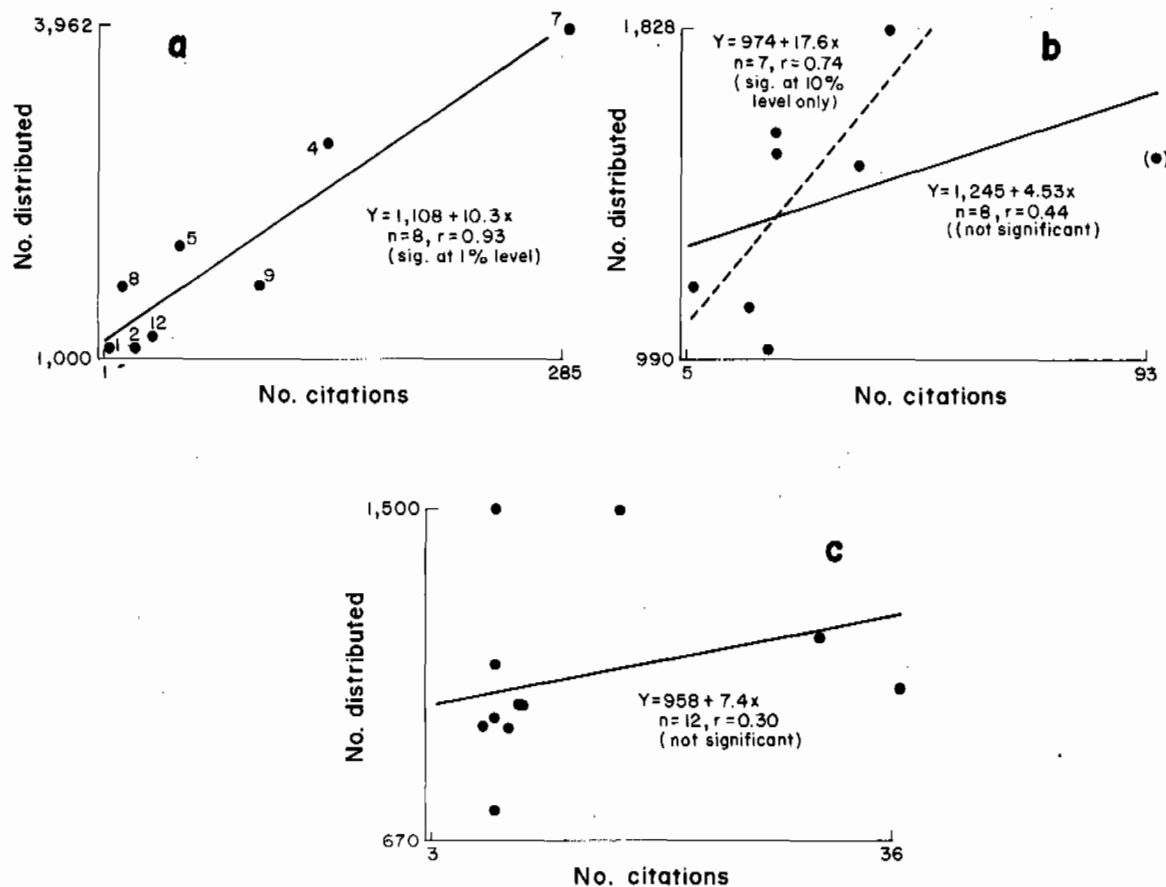


Fig. 3. Relationship between numbers of copies of ICLARM items distributed and numbers of citations for: a) Conference Proceedings; b) Studies and Reviews; c) Technical Reports. In Fig. 3b the dotted line shows the improved correlation by removing an outlier point (bracketed).

This phenomenon, together with the relatively high citation counts for the Conference Proceedings, highlights the value of this aspect of ICLARM's work. The high citation counts are also the consequence of the large number of individually authored papers in each volume.

The lack of correlation between citations and numbers of copies distributed for Studies and Reviews and Technical Reports is difficult to explain. Technical Reports are highly specialized and would perhaps have a small audience which is "saturated" at a low level of distribution. In the case of Studies and Reviews, the contents are broad and generally widely applicable. In fact, a better relationship between dissemination and citations is found ($r = 0.74$) if the outlier (the best performing item) is removed from consideration (Fig. 3b).

Most striking in these relationships is the intercept of the equations, ranging from 958 to 1,245. The best correlation, for Conference Proceedings, has an intercept of about 1,100. The preliminary "rule of thumb" that might be derived from these figures is that at least 1,000 copies of these ICLARM series publications must be distributed before citations can be expected. Above that minimum there may be an average of one citation per 10 additional copies distributed for Conference Proceedings, and one per 18 copies of Studies and Reviews.

Citation Growth Over Time

The increasing use of ICLARM items over time as suggested by Fig. 2 and further investigated in Table 3 can also be measured in terms of their citations at sequential relevant international conferences. For example, the papers presented at the Bellagio conference on the Biology and Culture of Tilapias held in 1980 included only 2 citations to ICLARM items in a total of 673 references. The next international conference on the subject was the International Symposium on Tilapia in Aquaculture, 1983. Citations to ICLARM items totalled 37 out of 478 references (7.7%) in papers which cited ICLARM items. This figure increased to 92 out of 753 references (12.2%) at the Second International Symposium on Tilapia in Aquaculture, 1987.

Similarly in the stock assessment field, the number of references to ICLARM items at the first major workshop on Theory and Management of Tropical Multispecies Stocks held in 1981 was only 15 out of 295 references (5.1%) in papers which cited ICLARM items. The next major workshop was on the use of Length-Based Methods in Fisheries Research, 1985. There was a total of 51 citations of ICLARM items out of 344 references (14.8%) in citing papers. In a compilation of papers resulting from stock assessment training in 1986 and 1987. (In Contributions to Tropical Fisheries Biology, FAO Fisheries Report 389, 1988), there were 178 citations of ICLARM items out of 582 references (30.1%) in citing papers.

These support the general trend illustrated in Table 3 of an increasing proportion over time of ICLARM citations in the major citing documents - conference papers and technical reports.

Overall, the 2,131 ICLARM citations comprised 5.0% of all citations (42,478) in the papers citing ICLARM.

Discussion

It should be stressed that the number of citations found using a manual search of ICLARM's library and staff reprint collections, represents a lower limit of the total since (i) not all the library's material could be searched in the two-week "sampling" period; and (ii) the library contains only a fraction of the world's recent aquatic science literature.

The sampling technique was to search material in the library and other collections most likely to yield citations, i.e., documents in related fields. For future ICLARM efforts in counting citations and for other institutions interested in such work, it would be useful to adopt a random sampling approach based on e.g., the library's serial holdings list, measuring the decline of new citations per effort (time) spent in successive searches, and extrapolating to estimate the total (D. Pauly, pers. comm.).

With regard to material not available in the ICLARM library, we cannot estimate what proportion of citations has been missed. Very few foreign-language journals/books were searched and we were subsequently informed that there were "many" citations to ICLARM material in Spanish literature from Central and Latin America. This problem, together with the nebulous nature of the boundaries of "fisheries" science (see Garfield (1980) and Fuseler - McDowell (1988) for a discussion of this aspect of Marine Biology, which overlaps considerably with fisheries science) make the determination of an upper limit to the total citations of ICLARM items very difficult.

A rule of thumb that might be derived from the present data is that only 10% of citations of ICLARM items on average appear in the SCI database, and that this percentage is a maximum in view of the fact that all citations not found in the library search were in the grey literature. Earlier, Pauly (1984) found the same proportionality: 31 of 307 citations to 50 of his articles appeared in SCI files.

Based on the present results, it is fair to say that ICLARM items have made a considerable impact in the literature relevant to the Center's areas of expertise. ICLARM items are well represented in the bibliographic databases AGRISIA and ASFA. The low number of items in the Scisearch and Social Scisearch databases is a reflection of ICLARM's mode of publication.

Only 36 ICLARM items (Contributions) have been published in the primary (referenced journal) literature to date; of those 33 were present in Scisearch or Social Scisearch and as noted earlier, 17 of them have been cited on 202 occasions altogether within the SCI database.

In recent years there have been over 300 citations/year of ICLARM items in the scientific literature. The citation rate has been growing over time not only in absolute terms but also in the proportion of ICLARM items in citing documents. We interpret this as an increasing influence of the Center's output. Importantly this output is being used (cited) worldwide and more in developing countries (~500) than North America (~400). In addition, the heavy use by FAO (~370) indicates that even more citations are set in the developing world context; the same is true of those citations (by external authors) in ICLARM publications (~200).

The large numbers of citations of nonjournal-article ICLARM items (1,840 citations) indicates that the Center's chosen mode of publication, primarily in its own series, has been successful.

Unfortunately, there are no comparable data to assess the relative impact or overall contribution of the Center.

Assessment of science in developing countries is generally based on the amount of inputs, especially when the inputs (funds) are from foreign assistance. Inputs constitute a crude measure but one which is justifiable in as much as it demonstrates that the countries concerned are doing science to a degree based on number of personnel, number of organizations, etc., as well as on level of funding (Moravcsik 1982).

At the organizational level, a measure of output is more important than input in justifying the continued existence of a scientific unit. Such measures may relate to activity, productivity or progress (Moravcsik 1982). Progress is virtually impossible to quantify, but even activity and productivity studies are rare in developing countries.

A study on various measures of scientific activity in 12 Middle Eastern countries (Frame 1980) -- number of publications, number of scientists and engineers, higher education enrollments and degrees conferred, and science and technology expenditures -- found that number of publications was the best indicator and was closely related to expenditure. In other words, productivity was a better indicator than measures of activity. The publication counts were from the ISI Science Citation Index (SCI) records "ignoring coverage of peripheral journals".

In Thailand, the SCI records were used as one measure of the output of science and technology (Yuthavong 1983). In 1981, 269 Thai articles (presumably in languages other than Thai) were included, which was more than for Malaysia, Singapore, the Philippines and Indonesia. It was felt that this was a rough indication of the country's scientific status using an "international yardstick".

There is a strong relationship between research & development expenditure and papers produced in the USA (McAllister and Wagner 1981), again based on SCI. The correlation could be even stronger in developing countries, when the substantial quantities of nonprimary literature generated are added.

Measuring productivity at the organizational and personal level is a well-respected tradition and often used as an incentive or prerequisite for promotion in some countries. In Indonesia, promotion is (partly) based on a publication score which gives more points for solo articles, chapters, etc. and less for a joint or junior authorship, etc. Rounsefell (1961) analyzed on a scale he created of 0.5-10 points/page, the various types of publications by a group of scientists of the U.S. Fish and Wildlife Service. Apparently this scaling was not further adopted, but remains a useful guide for comparing productivity of individuals and organizations in western settings. Given the importance of nonprimary literature in the third world, his scale would need substantial revision to be useful there.

Morgan and Hopkins (1986) compared productivity of various organizations in developing and "western developed" countries in terms of primary literature plus presented conference papers as a function of the numbers of research staff. They found that, on this basis, the number of publications per researcher in the countries sampled was close to that of researchers in

developed countries. Further, the real cost per publication was well within the same order of magnitude in most regions discussed.

However, the use of quantitative measures to assess output is by no means routine even in the western world. A recent report to the Advisory Board for the Research Councils of the UK (Martin et al. 1985) noted the need to use quantitative assessments of productivity for UK research centers dependent on government funds, to complement existing peer review mechanisms. The sample assessments used were the same as those used here - numbers of articles in bibliographic databases and citation analysis (for the UK as a whole, and its share of all articles written globally on particular sample subjects). The report met much criticism (A. Varley, pers. comm.). It was one of a series of articles based on SCI by different groups of authors about the state of British science, with some saying it was in decline, others that it was improving. A summary is contained in the latest in the series, and which concludes that there has been neither decline or improvement (Braun et al. 1989).

Citation analysis is a refinement of productivity measures because it assesses the *use* of publications by subsequent researchers. In some ways citation analysis is a measure of progress. Occasionally, citations may be peripheral or used to refute the previous findings, etc., but in general citation counts reflect the usefulness of a particular publication.

To date nearly all such analyses have been made using the SCI database. This database is complete enough in its coverage of western primary literature for regular use in assessing candidates for vacancies in various western organizations. On the other hand, attempts to use it in developing countries have been subject of much debate. At a meeting in 1985 it was observed that only about half of the "eligible" primary literature from developing countries was included (Moravscik 1986) in SCI. That figure does not agree with the results of the present survey in which almost all - 95% - of the ICLARM journal articles were present in SCI (this was a function of our choice of journals). However, in terms of citations, the SCI data covered only 43% of the total citations in the primary literature. Over 50% of those citations were in developing-country primary literature.

The only citation-based assessment of Southeast Asian Science (Arunachalam and Garg 1986) was carried out using the ISI Science Citation Index. Papers originating during 1979 and 1980 from Indonesia, Malaysia, the Philippines, Singapore and Thailand were itemized and citations (in SCI) retrieved for the five years 1979 to 1983. There were only 1,580 papers for the whole region for the two years, and 3,428 citations over the five-year citing period. Only 98 papers in biological sciences for the region were included, or about 50/year. With regard to citation "one eighth of the 447 papers from Thailand, 174 of the 452 from Malaysia and 109 of the 182 papers from Indonesia have gone uncited until the end of 1983" (Arunachalam and Garg 1986). In general the authors concluded that their results supported two common observations - that developing country literature is characterized by (i) a large percentage of uncited articles and very small fractions of highly cited papers, and (ii) a long gestation period between publishing and citation. "Long" is not defined, but the observation seems true for ICLARM items in as much as ICLARM journal articles have a longer average gestation period between publishing and citation than other document types.

Arunachalam and Garg (1985) examined 1979 and 1980 SCI data for Singapore separately, concluding that almost all scientific work there is reported in journals from the USA and Europe but is rarely cited.

Calleja (1980) investigated the number of Philippines articles and their citations in 1976 and 1977 SCI data. Calleja's rather strong conclusion was that "we have seen the wretched product of a wretched scientific effort."

A review of scientific literature in four Asian countries - Malaysia, Singapore, South Korea and Taiwan - by Davis and Eisemon (1989) also found that the contribution to "core" (that is to journals covered by ISI in the SCI) literature by such Asian countries was small using the SCI database. However, they also examined journals not in the SCI database and concluded that

such journals were useful for recording results of research of local importance, and that the papers therein cite grey (report and conference) literature extensively.

If citations to ICLARM items are any guide, only about one-fifth (22%) of the citing documents are in primary journals and of those SCI covers perhaps half. Thus, the conclusions of studies based on SCI relating to citations of developing-country documents may be based on only 10% of the available literature, and a much biased sample at that.

As for primary literature being the "international yardstick", it begins to lose meaning when one considers that the majority of (nonprimary) ICLARM items are being cited mainly in nonprimary literature around the world.

The most cited ICLARM items were published conference papers, making up over one-third of the cited documents, and followed in rank by technical reports. The major citing documents were technical reports, while conference papers and journal articles were roughly equal, but distant, second in rank. Thus, it can only be concluded that primary journal articles are not the "core" literature in developing-country fisheries research.

The mechanisms of biological research in developing countries may explain these phenomena. Much of this research is foreign assisted. Conditions of research grants usually include regular reporting and a final report at the end of the project. These reports may become a special project series (if there is more than one report) or be included in the series of the research organization involved - provincial or national government, or regional or international research institution. The same publishing fate is true of conference proceedings. This literature is consequently more elusive and scattered than journal literature. (Hence, the term "grey" or nonconventional literature for report and conference literature). Davis and Eisemon (1989) pointed out that this grey literature is extensively used in articles in local journals. Maclean (1989) noted that grey literature was as important as journal literature in a recent fisheries ecology text book from the USA (Longhurst and Pauly 1987). The present study shows that such grey literature is of importance in international fisheries research.

Conclusions

ICLARM items are well cited in a variety of document types around the world. The overall number of citations per year has been increasing and shows evidence of continuing to do so. In part this is due to the increasing number of ICLARM publications, offset, of course, by the obsolescence of earlier items. Coupled with this increase, the increasing proportion over time of ICLARM citations in documents which cite the Center's items, indicates an increasing influence of ICLARM's published output in the work of its clients - the fisheries research community. It is not possible to say what levels the citation rate and proportion of cited literature will eventually reach. It is encouraging, however, that both are still increasing.

ICLARM's conferences and their proceedings are clearly successful in concept and content. Conference proceedings papers are well cited and cited proportionately more in developing countries than are ICLARM journal articles. Thus, this is an appropriate role for a small center like ICLARM to pursue further.

The Studies and Reviews series has also proved itself in this survey as a useful one which should be continued.

Technical reports in general are clearly important in developing-country fisheries research. Developing countries cite the ICLARM series more than do developed countries. However, they have not been well cited. It may be simply that their "audience" is relatively small in view of their specialized nature. The option is to use primary literature outlets only, a cheaper route but requiring that only summary data be used. Much "raw" data as included in the full technical reports would be virtually lost. Also, a major objection to primary literature is that it is too expensive for researchers in developing countries to acquire and so is itself "lost" to these researchers. On the other hand, in view of the high citation counts already achieved through

primary literature articles, this outlet should be used to present at least part of ICLARM's research results to a greater extent than at present. Such articles could refer to the availability of the source data at ICLARM. The Center has already adopted the practice of buying sufficient reprints of articles to distribute to the ~ 300 free and exchange addressees who receive the various ICLARM series free. The problems are (i) that a reprint can become "lost" in a library or personal collection more easily than a numbered issue in a series; and (ii) that the research data may become "lost" within ICLARM. A proper data repository is one answer. However, if funds permit, a "data-rich" published technical report is a better safeguard, even if not highly used or cited.

Finally, the role of distribution of the Center's Conference Proceedings and to some extent Studies and Reviews in achieving citations has been demonstrated. The upper limit to this relationship is not known, but since the cost per copy of producing these documents decreases with increasing numbers, improved distribution would seem to have a double benefit. Ways of doing so warrant investigation.

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Appendix 1

Examples of ICLARM's citation performance
in the primary literature (top 10 journals) and
in various proceedings and by selected institutions

<i>Journals</i>	No. Citations
Aquaculture	68
Fisheries Research	58
Journal of Fish Biology	42
Canadian Journal of Fisheries and Aquatic Science and Special Publications	40
Bulletin of Marine Science	14
Environmental Biology of Fishes	12
US Fishery Bulletin	12
Transactions of the American Fisheries Society	11
Aquaculture & Fisheries Management	10
Australian Journal of Marine and Freshwater Research	9
<i>Proceedings</i>	
First Asian Fisheries Forum, 1986	46
First International Symposium on Tilapia, 1983	37
Second International Symposium on Tilapia, 1987	78
<i>Institutions</i>	
FAO (including regional commissions and projects)	368
UNESCO	26
University of the Philippines	19
ICES	15
SEAFDEC	9

Appendix 2

Geographical distribution of citations of ICLARM items according to the 52 countries of publication of citing documents. Citations in FAO and ICLARM documents are also included.

Australia	27	New Caledonia	3
Bangladesh	2	Nigeria	7
Belgium	10	Norway	1
Brazil	4	Peru	8
Brunei	6	Philippines	287
Canada	52	PNG	25
Chile	10	Puerto Rico	1
China	2	Senegal	4
Colombia	1	Singapore	6
Costa Rica	4	Solomon Islands	6
Denmark	32	South Africa	5
Ecuador	6	Sri Lanka	21
Egypt	19	Sweden	13
Ethiopia	1	Switzerland	1
Fiji	1	Taiwan	14
France	45	Thailand	2
French Polynesia	19	United Kingdom	183
Germany, Federal Republic	83	Uruguay	2
India	12	USA	349
Indonesia	29	Vanuatu	11
Israel	42	Virgin Islands	1
Italy	1	Yap	1
Ivory Coast	2		
Japan	10		
Kuwait	23	FAO	368
Madagascar	2	ICLARM	202
Malaysia	12		
Mexico	12		
Mozambique	1		
The Netherlands	128		
		*excluding self-citations	

Appendix 3

Citation counts of various ICLARM technical and external publications

ICLARM			No. Citations		
Contri- bution Number(s)	Item	Subject	Publication Date	Contri- bution	Noncontri- bution
ICLARM Conference Proceedings					
18	No. 1	Small boat designs	1979	1	
21	No. 2	Law of the Sea	1980	7	8
44,45	No. 4	Integrated farming	1980	24	112
59	No. 5	Fish behavior	1980	7	36
70	No. 7	Tilapia biology	1982	31	254
73	No. 8	Appropriate technology	1982	1	7
105,106	No. 9	Stock assessment	1982	56	39
254	No.12	Tilapia economics	1985	5	24
ICLARM Technical Reports					
61	No. 1	Milkfish	1981	9	
65,66	No. 2	Integrated farming	1981	9	
72	No. 3	Milkfish	1982	7	
85	No. 4	Catfish economics	1982	7	
86	No. 5	Integrated farming	1982	16	
92-96	No. 7	San Miguel Bay fisheries	1982	28	2
97-102	No. 8	San Miguel Bay fisheries	1982	8	
103	No. 9	San Miguel Bay fisheries	1982	6	
137	No.10	San Miguel Bay fisheries	1982	7	
138	No.11	San Miguel Bay fisheries	1982	7	
115	No.12	Solomon Islands tuna	1983	3	
219	No.13	Fish population parameters	1984	36	
ICLARM Studies and Reviews					
19	No. 1	Stock assessment	1979	93	
20	No. 2	Small-scale fisheries	1979	20	
33	No. 3	Mullet aquaculture	1980	16	
35	No. 4	Small scale fisheries	1980	20	
36	No. 5	Aquatic weeds	1980	5	
54	No. 6	Tilapia genetics	1981	42	
125	No. 7	Caribbean resources	1983	19	
143	No. 8	Population dynamics	1984	36	
388	No.10	Indonesian fisheries	1987	2	
2					
ICLARM Bibliographies					
57	No. 2	Pony fish	1981	8	
84	No. 3	Tilapia	1982	5	
253	No. 6	Tilapia	1985	1	
ICLARM Translations					
34	No. 1	Mussels	1980	9	
144	No. 2	Tilapia	1983	2	
External Publications					
7	Journal Article	Fish mortality (Pauly)	1980	152	
31	ICES Report	Fish mortality (Pauly)	1980	16	
32	Journal Article	Computer/fish growth (Pauly)	1980	80	
43	FAO Report	Stock assessment (Pauly)	1980	99	
52	USA Conference Paper	Stock assessment (Pauly)	1979	34	

Appendix 4

Numbers of citations of papers in ICLARM Conference Proceedings No. 7, The Biology and Culture of Tilapias (1982), in Scisearch and in the ICLARM literature search.

Senior Author	Scisearch citations to end 1987*	ICLARM literature search, Feb. 1988**
Pullin (Editor, i.e., book in toto)	3	25
Trewavas	3 - 14	21
Philippart	7	33
Noakes	8	13
Lowe-McConnell	8	20
Moriarty	0	
Chervinski	2	13
Jalabert	0	5
Bowen	9 - 17	29
Caulton	2 - 3	9
Hepher	3	15
Coche	4	24
Roberts	2	9
Avtalion	0 - 4	12
Lovshin	6	20
Mires	3	13
Guerrero	4	17
Pullin (statement)	0	6
TOTALS	68 - 85	285

*The search method was based on author and year only; validity of citations was confirmed for available citing papers only - the lower values in this column. Higher values represent maximum citations if cited authors had no citations of their other publications in the year of publication (1982).

** Includes primary literature