CHAPTER 7

THEMATIC ANALYSIS OF ANTARCTIC SCIENCE, OCEAN SCIENCE AND OCEAN ENGINEERING RESEARCH SPECIALTIES

7.1 INTRODUCTION

The research journals provide a macro level view of the main research themes, subfields and their linkages in a research domain. Therefore, a thematic analysis of a research specialty constitutes an important study. However, from this macro level view, it is extremely difficult to understand the linkages among various research fields within and between the subfields, among the concepts, etc. The journal network helps in delineating a knowledge domain, but a particular knowledge domain is further organized in a network of knowledge sub-domains. To understand these knowledge sub-domains, analysis of the indicators is required at the micro levels, like cognitive units in the form of representative words and their association patterns, leading to concept formations, activity structures in subject specialties.

This contextual analysis can be done through the study of words in titles or in abstracts of published articles. This can also be done through analyzing the keywords and indexing terms which can be seen as representing concepts described as ‘poles of research interest’, ‘research themes’, ‘problems domain’, etc. Therefore, this study is termed as content analysis and cognitive analysis. The assignment of an appropriate set of codes can be viewed as manifestation of an expert assessment of the scientific publication's cognitive structure. The network of co-occurrences between different codes, collected on a specific set of publications, allows a quantitative study of the structure of publication contents, in terms of the nature and strength of linkages.

A scientific field is characterized by a terminology of 'words', which signify concepts, operations, processes or methodologies. These important 'words' are reflected in the titles or abstracts, as a research worker attempts to convey or highlight the important and salient points of his/her paper. Co-occurrences of conceptual words in a large number of documents, in titles or abstracts of papers, signify the important relationships among these words. Thus, the structure depicted by the frequency of co-occurrence of conceptual words reveals important and interesting linkages among them and provides a further insight into the framework of a research field. These contextual analyses of co-occurrence of codes and of conceptual words enable the investigator to grasp the static and dynamic aspects of the manner in which scientists relate and place their work in a hierarchy of scientific research concepts. In addition, this method provides a direct quantitative way of linking the conceptual contents of publications. Hence, such a co-occurrence structure can represent research activities within a scientific area via depiction of concepts and topics, which are active, and the relations among them.

The network of co-occurrences between different words, collected on a specific set of publications, allows a quantitative study of the structure of publication contents in terms of the nature and strength of linkages between the pairs of words.

Word usage is more codified, and it seems always possible to distinguish between words with a major theoretical, methodological, or observational meaning within the context of a given specialty. It provides an analytical framework for carrying out dynamic analysis of the contents of articles (Leydesdorff 2001b). The keywords are often used to identify sub-domains of research specialties. For this study, the sub-domains were identified using agglomerative hierarchical clustering techniques, by grouping keywords at different levels (Noyons 2004, Noyons and Buter 2001).

This method labeled as ‘co-word analysis’, provides a direct quantitative way of linking the conceptual contents of publications, by comparing and classifying publications with respect to the occurrence of similar word-pairs. Hence, such a co-word structure can represent research activities within a scientific area. It does so through the depiction of the state-of-art research in that scientific area by delineating and underscoring the relations between various research themes. The co-word analysis was applied in this study to identify the emerging research areas in Ocean Science, Ocean Engineering and Antarctic Science. As a result, co-word approach was applied to uncover the topics/areas which were active. The picture that emerged depicted the micro level description of the specialty of a field. This is a valuable supplement in understanding the intellectual structure of the field (Figure 7.1).

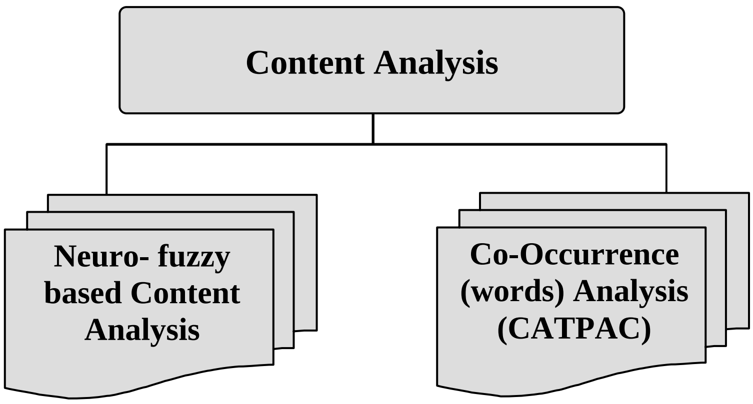

Figure 7.1 A schematic presentation of content analysis conducted on data

The first well-documented case of quantitative analysis of printed material goes back to the eighteenth-century in Sweden involving a collection of 90 hymns of unknown authorship entitled ‘Songs of Zion’. Content analysis or thematic analysis has numerous applications, spanning from marketing research, propaganda analysis and lately computer text analysis. In psychology, this technique has found three primary applications. The first is the analysis of verbal records to discover motivational, psychological or personality characteristics. The second is the use of qualitative data gathered in the form of answers to open-ended questions, verbal response to tests, thematic testing, and the third is concerned with the processes of communication in which content is an integral part (Krippendorff 1980).

7.2 MATERIALS AND METHODS

7.2.1 Neural Network-based Content Analysis

A real biological brain consists of a set of neurons, which are essentially biological "switches." In the simplest form, these switches can be either "on" or "off", but in more complicated models, the neurons can take on several "levels" of activation. When sufficiently stimulated, a neuron becomes active or "fires." Many of these neurons are connected to other neurons by neural pathways which can conduct stimulation from one neuron to another. Some of these pathways are in place at birth while others are formed during life as a result of experience. Because of these connections, activating some neurons in the brain generally results in activating others as well.

Artificial Neural Network (ANN) is an information-processing paradigm which mimics the parallel structure of the neuromorphic system of mammalian brain. Artificial neural networks are collections of mathematical models that emulate some of the observed properties of biological nervous systems and draw on the adaptive biological learning. It is composed of a large number of highly interconnected processing elements that are analogous to neurons and are tied together with weighted connections that are analogous to synapses.

Learning of biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well, where the training algorithm iteratively adjusts the connection weights (synapses). These connection weights store the knowledge necessary to solve specific problems. They are good pattern recognition engines and robust classifiers with the ability to generalize in making decisions about imprecise input data. They offer ideal solution to a variety of classification problems, such as speech, character and signal recognition. The advantage of ANNs lies in their resilience against distortions in the input data and their capability of learning.

To carry out the analysis in this research, a self-organizing neural network based algorithm (software)-**CATPAC**, was used to derive the normalized matrix of word associations (Woelfel 1998).

Each word that **CATPAC** sees is associated with an artificial "neuron" in **CATPAC's** simulated brain. As a result of the learning and forgetting rules, **CATPAC** will produce a 'brain" consisting of a network of interconnected neurons, each of which represents a word in the text. Some of these neurons will be tightly and positively connected, indicating that they are closely associated. Whenever one of them is activated, likelihood is great that the other will also be called to mind. Other neurons will be strongly negatively connected, indicated that one is very unlikely to be active when the other is active. Such neurons actually inhibit each other, so that activating a node will tend to de-activate other nodes to which it is negatively connected.

The neural network based algorithm makes it possible to retrieve episodic memories of the text document. Episodic memories differ from semantic memories by containing circumstantial info (who, what, when, where, etc.). Remembering episodic memories is generally more complex than recalling semantic memories, involving the evaluation of cued memories based upon the current goal (Raye et al 2000).

The algorithm works by passing a moving window of size n (in the present analysis 3-word window was used) through the text. In our study the text was a collection of all the titles of the papers. Each title was separated by delimiter '-1' to single out contributions from individual publications. Any time the window encounters a word, the neuron representing the word becomes active, connections among active neurons are strengthened, so the words that occur close to each other in the text tend to have higher level of connections. In subsequent scanning, if a word is encountered again, its value will go up, while in the absence of it, the activation level of words (neurons) goes down.

Because of its self-organizing characteristics, the algorithm can learn from the patterns of associations and generate normalized matrix. This matrix can be used to generate non-hierarchical clusters and to perform other network analysis.

A word association matrix was constructed by taking into account the connection strengths among the neurons that represent the words. It is not a simple co-occurrence matrix. This matrix not only represents the direct co-occurrences among the words, but also their indirect connections. For example if word 1 and word 2 co-occur, and word 2 and word 3 co-occur, but word 1 and word 3 never co-occur, nevertheless, algorithm links the words 1 and 3 because of their indirect connection through word 2. The resultant matrix is a generalized scalar product matrix normalized to approximately plus or minus 1.1. This may be treated as a generic similarities matrix. Cluster analysis of the resultant matrix gives a better expression about its purpose than the results obtained from simple co-occurrence of words. Like 'Pacific' and 'Ocean' do not convey much meaning independently but if the word 'wave' comes with this group, it conveys that 'wave research on Pacific Ocean'.

7.2.2 Title Words as Indicator of Research Activity

Titles constitute an important indicator of the content of a research article, and provided clue to the importance of the work. Numerous surveys have shown that bibliographies appearing in papers are one of the most valuable sources of information in literature searching (Garfield 1968). Words and citations are important indicators of research activity. Title words provide a special perspective on science and scholarly activity and for identifying research fronts (Garfield 1986). Search terms extracted from titles of articles are useful search terms for retrieval of information from databases and augmenting retrieval efficiency (Garfield 1990)

7.2.3 Generation of Matrix

Following neural network parameters were selected to generate the normalized matrix:

7.2.3.1 Significant Words

Zipf (1972) had described the frequency with which words occur in a given piece of literature. It was found that multiplying rank (r) of the words by its corresponding frequency of occurrence (f) gives a constant, C, i.e.

$$C = rf$$

Power Law behaviour provides a concise mathematical description of sheer dominance of few members over the total population (Luscombe 2002). The power law behaviour has been observed in different population distributions, these included income levels, relative sizes of cities (Zipf 1972), connectivity of nodes in large networks (Barabasi and Albert 1999).

In a typical distribution profile of words in a text document (in the present study it was a list of titles of papers published in peer-reviewed journals), the dominant word groups reflect the main theme of the document. Synonyms were clubbed together to derive a consolidated picture on the technical words. The words with high frequency of occurrence signify that the concepts which they depict are important. Among the highly ranked words, the cut-off values were determined to generate the matrix. The most frequent words occurring in the top layer were chosen to generate a matrix, which was used to carry out network analysis.

7.2.3.2 Window Size

The software algorithm works by passing a moving window of size *n* through a file. For example, for a window size of 4, and a slide size of 1, **CATPAC** would read words 1 through 4, then words 2 through 5, then words 3 through 6, and so on.

Any time a word is in the window, the neuron representing this word becomes active. Connections among active neurons are strengthened, so words that occur close to each other in the text tend to become associated in **CATPAC's** memory.

7.2.3.3 Slide Size

This prompts to ask how you would like the moving window to "slide" through the text. The number defines how many words the window will skip prior to reading the text. It may select any increment one may specify. For example, in case of a window of 5, and a slide size of 1, **CATPAC** would read words 1 through 5, 2 through 6, etc. In case a window size of 5 and a slide of 2, **CATPAC** would read words 1 through 5, then 3 through 7, etc.

7.2.3.4 Cycles

CATPAC's network analysis procedure works in the following manner: When words are present in the scanning window, the neurons assigned to those words are active, and the connection among all active neurons is strengthened. In addition, the activation of any neuron travels along the pathways or connections among neurons, and can in turn activate still other neurons whose associated words may not be in the window. These neurons can, in turn, activate still other neurons, and so on.

In an actual (biological) neural network, these processes go on in parallel and in real time, so that the signal coming into the network is spreading at different rates of speed throughout the network, and neurons are becoming active and inactive at different times. This process of delay is called *hysteresis*.

Very little cycling (or none at all as in the simple co-occurrence model) tends to find only highly superficial associations. Too much thinking (cycling), however, is not always a good thing, since **Catpac** can tend to see things as all pretty much alike if it is allowed to cycle too many times. In the analysis the default ‘cycle 1’ was used.

7.2.3.5 Clamping

When a word is found in the window, its neuron is activated. However, it can become de-activated again as the network goes through its normal processes, just as we see things, become aware of them, and then forget them (if we never forget, our mind would become so cluttered with images in only a few minutes that we cannot go on with life). Clamping the nodes (another word for neuron) would prevent them from turning off again. It is like writing yourself a note and holding it in front of you so you must always pay attention to the words in the note.

Chip-Head network options: The most generally useful neuron and some reasonable values for the three generally useful neurons (functional forms), and some reasonable values for the three general parameters have been chosen as defaults in the analysis.

7.2.3.6 Function Form

Out of four available function forms: a logistic varying between 0 and +1, a logistic varying between –1 and +1, a hyperbolic tangent function varying between –1 and +1, and a linear function varying between –1 and +1, the default one, i.e. logistic varying between 0 and +1, were used for the analysis.

7.2.3.7 Threshold

Each neuron in **Catpac** is either turned on by being in the moving window, or else receives inputs from other neurons to which it is connected. These inputs are transformed by a *transfer function*. After the inputs to any neuron have been transformed by the transfer function, they are summed, and, if they exceed a given threshold, that neuron is activated; otherwise it remains inactive. By lowering the threshold, you make it more likely for neurons to become activated; by raising the threshold, you make it less likely for neurons to become activated. Default threshold zero was used for the analysis.

7.2.3.8 Decay Rate

The decay rate specifies how quickly the neurons return to their rest condition (0.0), after being activated. The default rate of 0.9, means that each neuron, if not reactivated, will lose 90% of its activation in each cycle. Raising the rate makes them turn-off faster; lowering the rate means they are likely to stay on for a longer period.

7.2.3.9 Learning Rate

When neurons behave similarly, the strength of the connection between them is strengthened. The learning rate is how much they are strengthened in each cycle. The default 0.01 was used in the analysis.

7.2.4 Structural Equivalence Blocks as Specialty Areas

Lorrain and White (1971) proposed that if nodes are people, then social positions may be conceived as equivalence classes or ‘blocks’ of people who relate in a similar way to other such blocks. A concrete network can be transformed into a simplified model of itself where the nodes are combined into blocks and the relation(s) between nodes are transformed into relations between blocks.

Ideally, if two individuals (nodes) have exactly the same pattern of giving and receiving ties, they are structurally equivalent to each other. A set of such nodes jointly occupy a common position in the network. In principle, a set of positions, each occupied by nodes structurally equivalent to each other, can be determined. These positions are structurally non-equivalent. These are the blocks. The relations between nodes, both within and between blocks, can be used to construct the relations between the blocks. It is important to note that the reduction operates simultaneously on nodes and relations yielding a structural image that is simpler and amendable to more abstract analysis. In a network of individuals the members of a jointly occupied position (block) may not even know each other, just as two judges in different cities may not be acquainted or otherwise related-but share a common set of relational patterns, to prosecutors/defendants, jury members, and the like (Doreian and Fararo 1985).

Structural equivalence within a block implies that a block is formed with members that have a similar pattern of association, i.e., a similar pattern of giving and receiving ties. This is not the same for the groups that are formed through cluster analysis. In cluster grouping, only strong cohesive linkages among members result in their being in a particular group. In structural equivalence, the main criterion of a member being present in a block is that it has a strong association with another node. Thus, members are expected to be connected in a relationship among themselves through this external tie. Similar to cluster grouping, they are also expected to have linkages among themselves. But this is not a necessity to form a block/group, as it is in the case of cluster approach. Thus, this provides us a new method of looking at the relationships.

Words with strong structural connections were observed to be coming in a structurally equivalent block. Mainly the connections are associated with prosperities, types, effects or methods used for investigations. The blocks are categorized into plausible research areas. This assigning is done based on observing the strength of linkages among the words inside the blocks. Further the context of these words are seen from the titles, i.e., words which are embedded in the titles. This contextual understanding is a prerequisite exercise visualizes the research area. (Bhattacharya and Basu 1998)

The empirical, or operational, methods of reducing a concrete social network to a simpler image of itself are referred to as “block modeling.” The model proposed by Breiger et al (1975) relies on iterated correlations, while Burt and Schott (1990) proposed technique uses Euclidean distance. The method of Structural Equivalence which looks at the relationships among words as well as structural equivalent blocks is more appropriate for mapping research specialties at the micro levels, as it considers indirect linkages also. As proposed by Doreian and Thomas, 1985, the mean densities of the matrix were used as cut-off points to generate image matrices from the density of the blocks. These structures were viewed as reduced images of initial cognitive networks. These image matrices were used to draw network maps.

Ucinet software (Borgatti et al 2002) was used to study the structural equivalent blocks and calculating Freeman’s centrality values of the most-frequently used words.

7.2.5 Data Cleaning

7.2.5.1 Antarctic Science Dataset

SCI Database search with ‘Antarc*’ in title, from the year 1980 through 2004 (25 years), retrieved 10,942 records. The titles of all the articles were used for thematic analysis, Following synonyms and word variants were clubbed to bring similar words together. It ensured that the words with similar meaning were placed together and were not listed under variant entries.

- All ‘Antarctica’ words replaced by 'Antarctic'
- All ‘Island’ replaced by the word 'Islands'
- All 'Waters' replaced by the word 'Water'
- The Words- 'Art', 'Sp', 'Superba', 'Land', 'Late', 'Polar', 'Sub', 'Study' etc. were kept excluded from the analysis.
- No additional words were included in the top layer.

7.2.5.2 Ocean Science Dataset

For Ocean Science, a dataset of 4787 titles was used. Following corrections were made. The words like Marine’, ‘study’ ‘Sp’ were excluded, as these did not convey any meaning to the analysis. No additional words were included in the top layer.

Table 7.1 List of journals covered in SCI for the Year 2000 (Oceanography)

Sl. No.	Name of journals	Productivity (No. of articles)
1	Journal of Geophysical Research-Atmospheres	804
2	Journal of Geophysical Research-Space Physics	498
3	Journal of Geophysical Research-Solid Earth	468
4	Journal of Geophysical Research-Oceans	265
5	Limnology and Oceanography	204
6	Journal of Physical Oceanography	201
7	Ices Journal of Marine Science	192
8	Marine Geology	170
9	Bulletin of Marine Science	153
10	Journal of Geophysical Research—Planets	146
11	Deep-Sea Research Part I-Oceanographic Research Papers	142
12	Estuarine Coastal and Shelf Science	138
13	Continental Shelf Research	121
14	Deep-Sea Research Part Ii-Topical Studies In Oceanography	118
15	Marine Chemistry	117
16	Journal of Marine Systems	109
17	Ocean Engineering	93
18	Oceanology	85
19	Marine and Freshwater Research	83
20	Oceanologica Acta	66
21	Progress in Oceanography	64
22	New Zealand Journal of Marine and Freshwater Research	60
23	Polar Research	58
24	Paleoceanography	50
25	Helgoland Marine Research	47
26	Okeanologiya	38
27	Dynamics of Atmospheres and Oceans	38
28	IEEE Journal of Oceanic Engineering	37
29	Tellus Series A-Dynamic Meteorology and Oceanography	36
30	Journal of Sea Research	33
31	Journal of Marine Research	32
32	Geo-Marine Letters	32
33	Izvestiya Akademii Nauk Fizika Atmosfery I Okeana	31
34	Marine Geophysical Researches	20
35	Marine Georesources and Geotechnology	19
36	Oceanus	10
37	Atmosphere-Ocean	9
	Total records	4787

7.2.5.3 Ocean Engineering Dataset

Titles of all the 464 records, separated by '-1' delimiters, were used to do the analysis of dataset of Ocean Engineering. The journal set used for the analysis is given in the Table 7.2.

Following corrections_were made to make the data ready for the analysis:

1. Following synonymous words and word variants were clubbed together to consolidate the dataset. It ensured that the words with similar meanings were together and were not listed under variant entries:
   - 'Model', 'Modeling' and 'Models' were clubbed together in 'Models'.
   - 'Wave' and 'waves' were clubbed together in 'Waves'.
   - 'Measurement' was added to 'Measurements'
   - Under and water have been kept together

2. Following words were excluded from the analysis, as these were not content-related words:
   - water, study, under, based, marine, sea, ocean, numerical, analysis, flow

3. Following words were included as these contributed to the conceptual understanding of the most frequently used words lying at the top the distribution list:
   - Wind, ship, Boussinesq, Doppler, dimensional

Table 7.2 List of journals covered in SCI for the Year 2000 (Ocean Engineering)

Sl No.	Name of the journals	No. of articles
1.	Journal of Atmospheric and Oceanic Technology	139
2.	Ocean Engineering	93
3.	Coastal Engineering	57
4.	Journal of Waterway Port Coastal and Ocean Engineering- ASCE	45
5.	Naval Research Logistics	44
6.	IEEE Journal of Oceanic Engineering	37
7.	Proceedings of The Institution of Civil Engineers-Water Maritime and Energy	30
8.	Marine Georesources and Geotechnology	19

7.3 RESULTS AND DISCUSSION

7.3.1 Antarctic Science

The rank-ordered list of most-frequently used words is given in Table 7.3. ‘Ice’, ’Sea’, ’Islands’ are the most-frequently used words. Though, the word ‘composition’ is at the bottom of the list (Table 7.3), it is the most-connected word in Antarctic science (Table 7.6) with Freeman’s degree centrality value of 10.56. Top 35 words were selected to generate the matrix of word-associations, which was subsequently used for network analysis.

Table 7.3 Most-frequently used words in Antarctic Science Subject Specialty

Total Words	13672
Total Unique Words	35
Total Episodes	13669
Total Lines	27324

Threshold	0.000
Restoring Force	0.100
Cycles	1
Function	Sigmoid (-1 - +1)
Clamping	Yes

Descending Frequency List				
			CASE	
WORD	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Ice	1681	12.3	5318	38.9
Sea	1040	7.6	3683	26.9
Islands	921	6.7	3052	22.3
Water	628	4.6	2292	16.8
East	621	4.5	22.6	16.1
Peninsula	463	3.4	1698	12.4
Southern	444	2.9	1679	12.3
Species	396	2.9	1439	10.5
Krill	393	2.9	1358	9.9
Distribution	376	2.8	14446	10.6
Ocean	360	2.6	1312	9.6
Ross	359	2.6	1363	10.0
Fish	353	2.6	1246	9.1
Marine	320	2.3	1178	8.6
Ozone	294	2.2	9.3	6.6
West	291	2.1	1066	7.8
Evidence	284	2.1	1072	7.8
Surface	282	2.1	1058	7.7
Lake	281	2.1	947	6.9
Temperature	275	2.0	1041	7.6
Implications	264	1.9	1030	7.5
Bay	263	1.9	1011	7.4
Weddell	256	1.9	981	7.2
Shelf	254	1.9	968	7.1
Euphausia	251	1.8	929	6.8
Snow	246	1.8	896	6.6
Polar	242	1.8	888	6.5
Observations	238	1.7	883	6.5
Station	237	1.7	900	6.6
Measurements	229	1.7	862	6.3
Sheet	229	1.7	879	6.4
Composition	228	1.7	886	6.5
Mcmurdo	227	1.7	865	6.3
Changes	226	1.7	881	6.4
Study	220	1.6	852	6.2

Alphabetically Sorted List				
			CASE	
WORD	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Bay	263	1.9	1011	7.4
Changes	226	1.7	881	6.4
Composition	228	1.7	886	6.5
Distribution	376	2.8	1446	10.6
East	621	4.5	2206	16.1
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Weddell	256	1.9	981	7.2
West	291	2.1	1066	7.8

A four blocks model solution was found to be optimum at R^2=0.998. Table 7.4 depicts the blocks assignments of the words. The density table was dichotomized using the mean density of the table - 0.33 using the following rule (Table 7.5).

Rule: y(i,j) = 1 if x(i,j) > -0.33, and 0 otherwise.

Table 7.4 Block Assignments for Antarctic Science

Block 1	Ice, Island, Sea Water
Block 2	Euphausia (superba), Krill, Measurement
Block 3	Bay, Distribution, East, Implication, Lake, Marine Ocean, Peninsula, Polar, Ross, Sheet, Shelf, Snow, South, Species, Study, Surf, Weddle Sea, West,
Block 4	Changes, Composition, Evidence, Fish, McMurdo, Observation, Ozone, Station, Temperature

Table 7.5 Binary matrix derived from the valued matrix

	Block 1	**Block 2**	**Block 3**	**Block 4**
Block 1	1	0	1	0
Block 2	0	1	0	1
Block 3	1	0	1	0
Block 4	0	1	0	1

The network diagram is given in the Figure 7.2. Two distinct blocks have come out. The standard deviation of 0.74 indicates a wide range of its variability. The network map has generated two distinct clusters, one between block 1 and block 3, and the other between block 2 and block 4. Block 1 contains words like of ‘Ice’, ‘island’ and ‘sea’ ‘water’ while block 3 mostly identifies geographical locations, indicating prevalence of research on this subject in the stated locations like Peninsular regions, Ross islands, etc 'Changing' scenarios have been the focus of substantial amount of research.. This may be due to the worldwide concerns about 'global warming' and its relation with Antarctic ice shelf. Substantial research has been done in and around the McMurdo station of the USA, which is Antarctica's largest community[1]. USA sends maximum number of expedition members to Antarctica. They maintain a huge research base in the icy continent, and largest producer of scientific information, as evident through published papers on Antarctica Continent (Dastidar 2007). Block 2 consists of word like 'Krill' and its scientific name '*Euphausia*' 'measurement' which is linked with the block 4 consisting of words like 'changes', 'composition', 'fish', etc. It is evident from this block modelling that there is prevalence of research on the biological resources like Krill, fish, etc in the Antarctic water.

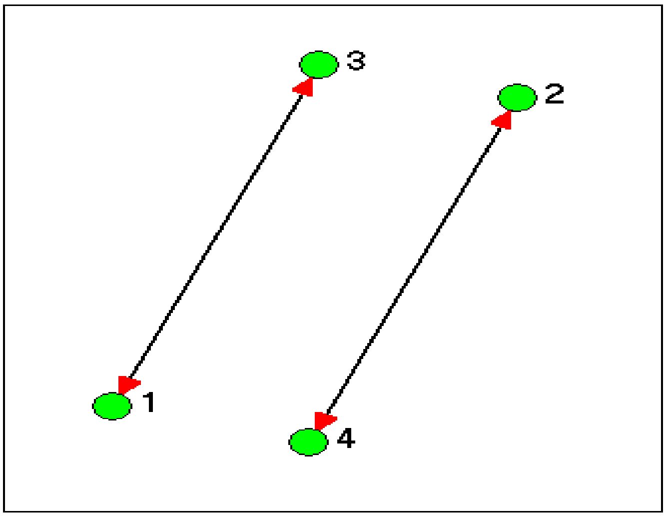

Figure 7.2 Network map of thematic blocks in Antarctic Science Research

[1] It is built on the bare volcanic rock of Hut Point Peninsula on Ross Island, the farthest south solid ground that is accessible by ship. Established in 1956, it has grown from an outpost of a few buildings to a complex logistics staging facility of more than 100 structures including a harbour, an outlying airport (Williams Field) with landing strips on sea ice and shelf ice, and a helicopter pad. There are above-ground water, sewer, telephone, and power lines linking buildings (http://astro.uchicago.edu/cara/vtour/mcmurdo).

Centrality of the top 35 words is given in Table 7.6. ‘Composition’ is the most-connected word with a centrality value of 10.56, followed by the words ‘Sea’, ‘Ice’, and ‘Water’, signifying its use with many other words. It is evident that considerable amount of research is underway to uncover the ‘composition’ of various attributes.

Table 7.6 Freeman’s degree centrality, normalised degree centrality and share of centrality of words in Antarctic Science subject specialty

Words	Degree	Normalised Degree	Share
Sea	5.586	16.428	-0.216
Ice	5.570	16.382	-0.215
Water	4.964	14.600	-0.192
Island	4.948	14.554	-0.191
East	4.935	14.515	-0.191
Southern	4.697	13.814	-0.182
Ross	4.653	13.686	-0.180
Implication	4.613	13.567	-0.178
Marine	4.607	13.549	-0.178
Species	4.573	13.449	-0.177
Penins	4.562	13.418	-0.176
Ocean	4.558	13.405	-0.176
Distribution	4.545	13.369	-0.176
Snow	4.543	13.360	-0.176
Sheet	4.479	13.172	-0.173
Surface	4.446	13.077	-0.172
Lake	4.429	13.028	-0.171
Weddel	4.407	12.963	-0.170

Table 7.6 (Continued)

Words	Degree	Normalised Degree	Share
Shelf	4.354	12.805	-0.168
West	4.336	12.752	-0.168
Bay	4.224	12.423	-0.163
Study	4.148	12.200	-0.160
Polar	4.058	11.937	-0.157
Composition	10.563	-31.068	0.408
Evidence	-10.577	-31.108	0.409
Temperature	-10.628	-31.259	0.411
Change	-10.826	-31.840	0.419
Mcmurdo	-10.858	-31.934	0.420
Station	-10.862	-31.947	0.420
Observation	-10.966	-32.252	0.424
Fish	-11.082	-32.595	0.428
Ozone	-11.277	-33.168	0.436
Measurement	-11.310	-33.265	0.437
Euphausia	-11.463	-33.715	0.443
Krill	-11.687	-34.372	0.452

7.3.2 Ocean Science

The rank-list of most-frequently used words is given in Table 7.7 words ‘ocean’, ‘model’. It is evident that ‘Modelling’ is an important research activity in Ocean science and also in Ocean engineering (Table 7.14). ‘Atlantic’ and ‘Pacific’ are also in the most-used word list, signifying substantial research on these oceans. Top 35 most-used words were taken to generate the matrix for social network analysis.

Table 7.7 Most-frequently used words in Ocean Science Subject Specialty

Total Words	5892
Total Unique Words	35
Total Episodes	5889
Total Lines	10275

Threshold	0.000
Restoring Force	0.100
Cycles	1
Function	Sigmoid (-1 - +1)
Clamping	Yes

Descending Frequency List				
			CASE	
Word	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Sea	588	10.0	1774	30.1
Ocean	313	5.3	1121	19.0
Model	302	5.1	1032	17.5
Water	238	4.0	859	14.6
Surface	208	305	763	13.0
Atlantic	200	304	708	12.0
North	196	3.3	738	12.5
Measurements	185	3.1	651	11.1
Observations	175	3.0	632	10.7
Distribution	174	3.0	646	11.0
Marine	173	2.9	561	9.5
Data	164	2.8	603	10.2
Variability	160	2.7	608	10.3
Pacific	155	2.6	581	9.9
Study	154	2.6	593	10.1
Effects	144	2.4	516	8.8
Wave	138	2.3	468	7.9
Analysis	136	2.3	519	8.8
Modeling	134	2.3	510	8.7
Transport	134	2.3	487	8.3
Waves	130	2.2	472	8.0
Atmospheric	129	2.2	467	7.9
Field	129	2.2	447	7.6
Deep	126	2.1	478	8.1
Coastal	123	2.1	441	7.5
Wind	123	2.1	445	7.6
High	121	2.1	426	7.2
Southern	121	2.1	453	7.7
Ice	120	2.0	392	6.7
Production	119	2.0	440	7.5
Solar	119	2.0	389	6.6
Carbon	118	2.0	409	6.9
Organic	118	2.0	412	7.0
Sediments	113	1.9	431	7.3
Continental	112	1.9	412	7.0

Alphabetically Sorted List				
			CASE	
Word	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Analysis	136	2.3	519	8.8
Atlantic	200	3.4	708	12.0
Atmospheric	129	2.2	467	7.9
Carbon	118	2.0	4.9	6.9
Coastal	123	2.1	441	7.5
Continental	112	1.9	412	7.0
Data	164	2.8	603	10.2
Deep	126	2.1	478	8.1
Distribution	174	3.0	646	11.0
Effects	144	2.4	516	8.8
Fifld	129	2.2	447	7.6
High	121	2.1	426	7.2
Ice	120	2.0	392	6.7
Marine	173	2.9	561	9.5
Measurements	185	3.1	651	11.1
Model	302	5.1	1032	17.5
Modeling	134	2.3	510	8.7
North	196	3.3	738	12.5
Observations	175	3.0	632	10.7
Ocean	313	5.3	1121	19.0
Organic	118	2.0	412	7.0
Pacific	155	2.6	581	9.9
Production	119	2.0	440	7.5
Sea	588	10.0	1774	30.1
Sediments	113	1.9	431	7.3
Solar	119	2.0	389	6.6
Southern	121	2.1	453	7.7
Study	154	2.6	593	10.1
Surface	208	3.5	763	13.0
Transport	134	2.3	487	8.3
Variability	160	2.7	608	10.3
Water	238	4.0	859	14.6
Wave	138	2.3	468	7.9
Waves	130	2.2	472	8.0
Wind	123	2.1	445	7.6

A 5-block solution was obtained at R^2 value of 0.969. Increasing the number of blocks did not give any additional information. The block assignments of the words are given in the Table 7.8. The block 5 is a block of names depicting name of the geographical region, like ‘Atlantic’, ‘Pacific’, ‘Northern’ region and some_activities like ‘modelling’ etc, which is linked to all other block. Block 4 is the block of actions, dominated by the words like analysis, observations, waves, effects, etc. The block is linked to all other blocks. The matrix was dichotomized with the following rule. -0.1 was the density of the matrix.

Rule: y(i,j) = 1

if x(i,j) > -0.1, and 0 otherwise.

The binary matrix is given in Table 7.9 and the corresponding network diagram is depicted in the Figure 7.3. The network map shows interconnection between the blocks, signifying interdependence of the blocks, unlike Antarctic science. 0.23 was the standard deviation, showing less variability. The centrality values are given in Table 7.10. The words ‘model’ ‘Atlantic’ were the most-connected words showing all around work in modelling activities and also on ‘Atlantic Ocean’. The Network Centralization value was found as 11.32.

Table 7.8 Block assignment table for Ocean Science

Block 1	Measurements
Block 2	Sediments
Block 3	Carbon, Coastal, Continental, Data, Deep, Distribution, Ice, Modeling, Organic, Production, Southern
Block 4	Analysis, Atmospheric, Effects, Field, High, Observations, Solar, Waves, Wind
Block 5	Atlantic, Marine, Model, North, Ocean, Pacific, Sea, Study, Surface, Transport, Variability, Water

Table 7.9 Binary matrix derived from the valued matrix

	Block 1	**Block 2**	**Block 3**	**Block 4**	**Block 5**
Block 1	0	1	1	1	1
Block 2	1	0	1	1	1
Block 3	1	1	0	1	1
Block 4	1	1	1	0	1
Block 5	1	1	1	1	0

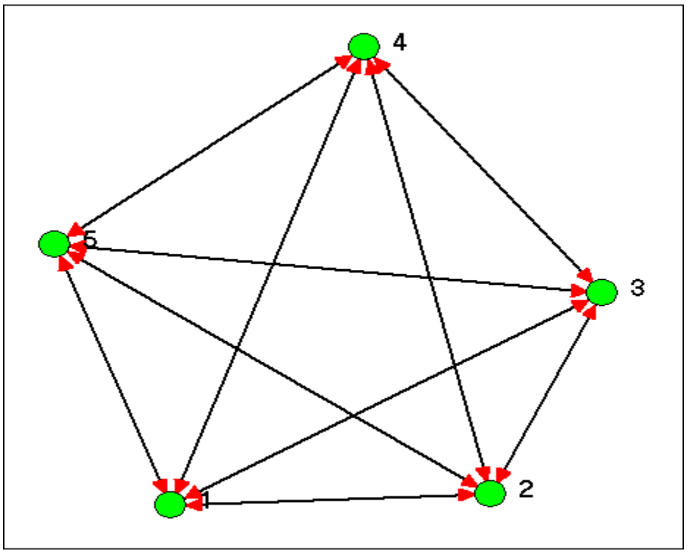

Figure 7.3 Network map of thematic blocks in Ocean Science Research

Table 7.10 Freeman's degree centrality, normalised degree centrality and share of centrality of words in Ocean Science Subject Specialty

Words	Freeman's degree centrality	Normalized degree	Share
Model	3.163	9.303	-0.194
Atlantic	2.705	7.956	-0.166
Ocean	2.555	7.515	-0.157
Transport	2.489	7.320	-0.153
Surface	2.478	7.290	-0.152
Study	2.213	6.509	-0.136
Variability	2.144	6.307	-0.132
Water	2.096	6.165	-0.129
Marine	2.011	5.915	-0.123
Sea	1.928	5.672	-0.118
Pacific	1.850	5.441	-0.113
Data	1.846	5.429	-0.113
Ice	1.829	5.379	-0.112
Distribution	1.781	5.238	-0.109
Modeling	1.579	4.645	-0.097
Southern	1.292	3.801	-0.079
Continental	1.266	3.725	-0.078
Organic	1.238	3.640	-0.076
Production	1.221	3.592	-0.075
Carbon	1.182	3.478	-0.073
Coastal	1.153	3.391	-0.071
Deep	1.128	3.317	-0.069
Sediments	0.715	2.103	-0.044
Measurements	-4.296	-12.635	0.263
Analysis	-4.463	-13.127	0.274
Observations	-4.979	-14.643	0.305
Wind	-5.358	-15.757	0.329
Atmospheric	-5.432	-15.976	0.333
Waves	-5.512	-16.210	0.338
High	-5.685	-16.721	0.349
Field	-5.796	-17.048	0.355
Wave	-6.013	-17.685	0.369
Effects	-6.430	-18.913	0.394
Solar	-6.758	-19.877	0.414

7.3.3 Ocean Engineering

The rank-ordered list of the frequency of words is given in Table 7.11. The research work shows a substantial contribution on ‘Atlantic’ and ‘Pacific’ Ocean. There was less research work on Indian Ocean and other oceans. ‘Measurement’ of ocean parameters and resources, its distribution and variability constituted the major scheme of research activity.

From the rank-ordered list, top 26 unique words were chosen to generate the matrix. Wave (18%) and Modeling (13%) were the most researched area in Ocean Engineering. Freeman’s centrality values are given in Table 7.14. It also showed the highest values for the words ‘Waves’ and ‘Models’. This revealed that the words ‘Waves’ and ‘Models’ were the most-connected words in the area of Ocean Engineering and these signified their importance for other areas of research. ‘Measurements’ and ‘data generation’ were the other areas of important research activity.

Block Modelling of the matrix was performed to derive the blocks of the ‘words’ with perceptible associations. Four blocks model gave optimum R^2 value of 0.945. The first block having larger density, consisted of the words ‘Models’ ‘Waves’ and ‘Wind’. The second block consisted of only ‘Coastal’, while the third block consisted of words like ‘Acoustic’, ‘Boussinesq equation’, ‘Current’, etc. and the fourth block consisted of ‘Data’, ‘Effects’, ‘Measurements’, etc. which were related to data and measurements. Block 1, which consisted of ‘Models’, ‘Waves’ and ‘Wind’ were linked to all other words, showing its importance in the subject specialty. Freman’s Degree centrality of the words is given in Table 7.17. The same words constituted the central block (Figure 7.4). The network centralization is 18.3%.

Table 7.11 Most frequently used words in Ocean Engineering subject specialty

Total Words	523
Total Unique Words	26
Total Episodes	521

Restoring Force	0.100
Cycles	1
Function	Sigmoid (-1 - +1)
Clamping	Yes

Descending frequency list of word				
	CASE			
WORD	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Waves	94	18.0	208	39.9
Models	67	12.8	169	32.4
Measurements	30	5.7	78	15.0
Data	26	5.0	73	14.0
Effects	23	4.4	66	12.7
Surface	19	3.6	55	10.6
Underwater	19	3.6	47	9.0
Time	18	3.4	52	10.0
Radar	17	3.3	50	9.6
Acoustic	16	3.1	43	8.3
Nonlinear	15	2.9	43	8.3
Sediment	15	2.9	40	7.7
Method	14	2.7	38	7.3
Velocity	14	2.7	42	8.1
Coastal	13	2.5	39	7.5
Distribution	13	2.5	32	6.1
Pressure	12	2.3	34	6.5
Temperature	12	2.3	36	6.9
Current	11	2.1	31	6.0
Dimensional	11	2.1	33	6.3
Doppler	11	2.1	33	6.3
Observations	11	2.1	32	6.1
Order	11	2.1	28	5.4
Ship	11	2.1	29	5.6
Wind	11	2.1	33	6.3
Boussinesq	9	1.7	27	5.2

Alphabetically sorted list of word				
			CASE	
WORD	**FREQ**	**PCNT**	**FREQ**	**PCNT**
Acoustic	16	3.1	43	8.3
Boussinesq	9	1.7	27	5.2
Coastal	13	2.5	39	7.5
Current	11	2.1	31	6.0
Data	26	5.0	73	14.0
Dimensional	11	2.1	33	6.3
Distribution	13	2.5	32	6.1
Doppler	11	2.1	33	6.3
Effcts	23	4.4	66	12.7
Measurements	30	5.7	78	15.0
Method	14	2.7	38	7.3
Models	67	12.8	169	32.4
Nonlinear	15	2.9	43	8.3
Observations	11	2.1	32	6.1
Order	11	2.1	28	5.4
Pressure	12	2.3	34	6.5
Radar	17	3.3	50	9.6
Sediment	15	2.9	40	7.7
Ship	11	2.1	29	5.6
Surface	19	3.6	55	10.6
Temperature	12	2.3	36	6.9
Time	18	3.4	52	10.0
Underwater	19	3.6	47	9.0
Velocity	14	2.7	42	8.1
Waves	94	18.0	208	39.9
Wind	11	2.1	33	6.3

Table 7.12 Block assignments table for Ocean Engineering

Block No 1	Models, Waves, Wind
Block No 2	Coastal
Block No 3	Acoustic, Boussinesq, Current, Dimensional, Distribution, Doppler, Method, Observations, Order, Pressure, Radar, Sediment, Ship, Temperature, Underwater, Velocity.
Block No 4	Data, Effects, Measurements, Nonlinear, Surface, Time

The valued matrix was dichotomized using the following rule. The average density within the blocks are -0. 0070 for ocean engineering.

Rule: y(i,j) = 1

if x(i,j) > -0.0070, and 0 otherwise.

Table 7.13 Binary matrix derived from the valued matrix

	Block 1	**Block 2**	**Block 3**	**Block 4**
Block 1	1	1	1	1
Block 2	1	1	0	0
Block 3	1	0	0	0
Block 4	1	0	0	0

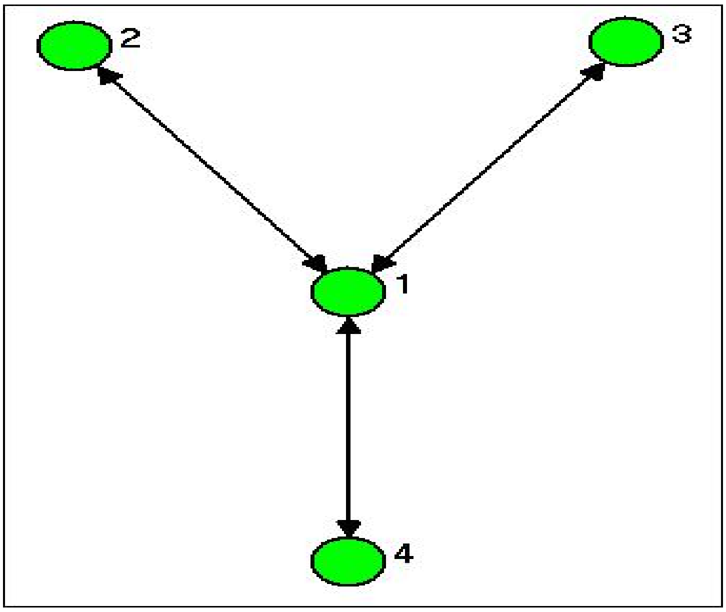

Figure 7.4 Network map of thematic blocks in Ocean Engineering Research

Table 7.14 Freeman's degree centrality, normalized degree centrality and share of centrality of words in Ocean Engineering Subject Specialty

Words	Freeman's degree centrality	Normalized degree	Share
Waves	4.050	16.200	-0.893
Models	3.692	14.768	-0.814
Wind	2.768	11.070	- 0.610
Effects	-0.023	-0.092	0.005
Measurements	-0.138	-0.552	0.030
Data	-0.158	-0.632	0.035
Time	-0.170	-0.678	0.037
Nonlinear	-0.443	-1.770	0.098
Surface	-0.479	-1.917	0.106
Coastal	-0.487	-1.946	0.107
Sediment	-0.547	-2.189	0.121
Radar	-0.641	-2.563	0.141
Pressure	-0.662	-2.649	0.146
Boussinesq	-0.678	-2.713	0.150
Current	-0.760	-3.042	0.168
Method	-0.765	-3.059	0.169
Velocity	-0.802	-3.208	0.177
Dimensional	-0.835	-3.340	0.184
Observations	-0.852	-3.409	0.188
Order	-0.879	-3.515	0.194
Temperature	-0.888	-3.553	0.196
Underwater	-0.912	-3.650	0.201
Distribution	-0.961	-3.844	0.212
Ship	-0.963	-3.852	0.212
Acoustic	-0.970	-3.882	0.214
Doppler	-1.031	-4.123	0.227

7.4 CONCLUSIONS

The thematic analysis has been conducted using a dataset of 10,942 titles in Antarctic science, 4787 titles in Ocean Science, and 464 titles in Ocean engineering. From these titles the unique words were identified as 13672 for Antarctic science, 5892 for Ocean Science, and 523 for Ocean engineering. From the list of unique words, top 35-words each in Antarctic science and Ocean science and top 26-words in Ocean engineering were taken for the analysis. Study revealed following words as the frequently used words: ‘Ice’ (1681), ‘Sea’ (1040), ‘Islands’ (921), ‘Water’ (628) in Antarctic science; ‘Sea’ (588), ‘Ocean’ (313), ‘Model’ (302) in Ocean science and ‘Waves’ (94), ‘Models’ (67) and ‘Measurements’ (30) in Ocean engineering. The Freeman’s degree centrality and normalised degree centrality have been calculated for all the selected words in these subject specialties.

Block to block network maps have also been generated in each of the three subject specialties to find the linkages of the words in one block with those of the other blocks. The network map in Antarctic science has generated two distinct linkages. One was between Block 1 (having words like Ice, island, sea, water), Block 3 (having location-related words like Peninsula, Polar, Bay). The other was between Block 2 (having words like Krill, measurement) and Block 4 (having words like change, composition, fish). The first depicts the prevalence of research interests in subjects like Peninsular regions, Ross islands, etc, while the second has depicted prevalence of research on the biological resources like Krill, fish, etc. in the Antarctic water. In Ocean science, the block to block network map has depicted a interconnected structure wherein each block has connections with the other four blocks. Thus, the word ‘Measurement’ (Block 1) is being used with words like sediments (Block 2), carbon (block 3) and surface (block 4). The network map in Ocean engineering has depicted an altogether different picture wherein Block 1 (having words ‘models’, ‘waves’, ‘wind’) is connected with other three blocks — Block 2 (having words ‘coastal’), Block 3 (having words like ‘acoustic’, ‘Doppler’, ‘velocity’) and Block 4 (having words ‘Data’, ‘Measurements’, ‘Effects’, ‘Nonlinear’). Thus in Ocean engineering the research subjects include words like Doppler effects, Nonlinear models, coastal winds, etc. Thus this method has been able to map the research specialties at the micro-level and has provided a further insight into the framework of a research field.