Social network analysis of ICES Expert Groups

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Final project report

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Content

Abbreviations

ACOM	ICES Advisory Committee
EBA	Ecosystem-based approach
EGs	ICES Expert Groups (including WGs, SGs, WKs and OGs)
GES	Good environmental status
ICES	International Council for the Exploration of the Sea
IEA	Integrated ecosystem assessment
MSFD	Marine Strategy Framework Directive
OGs	ICES Operational Groups
SCICOM	ICES Science Committee
SGs	ICES Study Groups
SNA	Social network analysis
WGs	ICES Working Groups
WKs	ICES Workshops

Figures

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1 Introduction

Thanks to the ICES Science Fund 2014, we realized the first extensive social network analysis of ICES Expert Groups (EGs). Network analysis has proved to be a suitable tool to identify structural patterns of relationships within huge organizations. A detailed research design including research questions and analysis steps was developed during meetings with Jörn Schmidt (Uni Kiel) and a personal meeting in Kiel, Germany on 13.8.2014. To support the success of the study, Friederike Lempe, the leading scientist in the project, stayed at the Stockholm Resilience Centre from August 24th to September 6th 2014 and was supervised by Örjan Bodin, one of the leading experts in social network analysis (SNA).

For the analysis, we used ICES participation data from 2010 until 2013 representing active participation of individual scientists in ICES EGs. Data sets were provided by the ICES secretariat. Statistical analysis and data visualization were realized with UCINET and NETDRAW software. In a first step, the huge data sets had to be cleaned and processed in order to guarantee a proper statistical analysis. The four different visualized networks consisted of around 120 nodes that represented the different ICES EGs. These EGs were linked to each other through individual memberships. One person attending two different EGs in one year therewith created a link between these two EGs. In the following figures, we have visualized the links between all the EGs from 2010 to 2013, just to give an impression of the huge network that ICES was based on, these years.

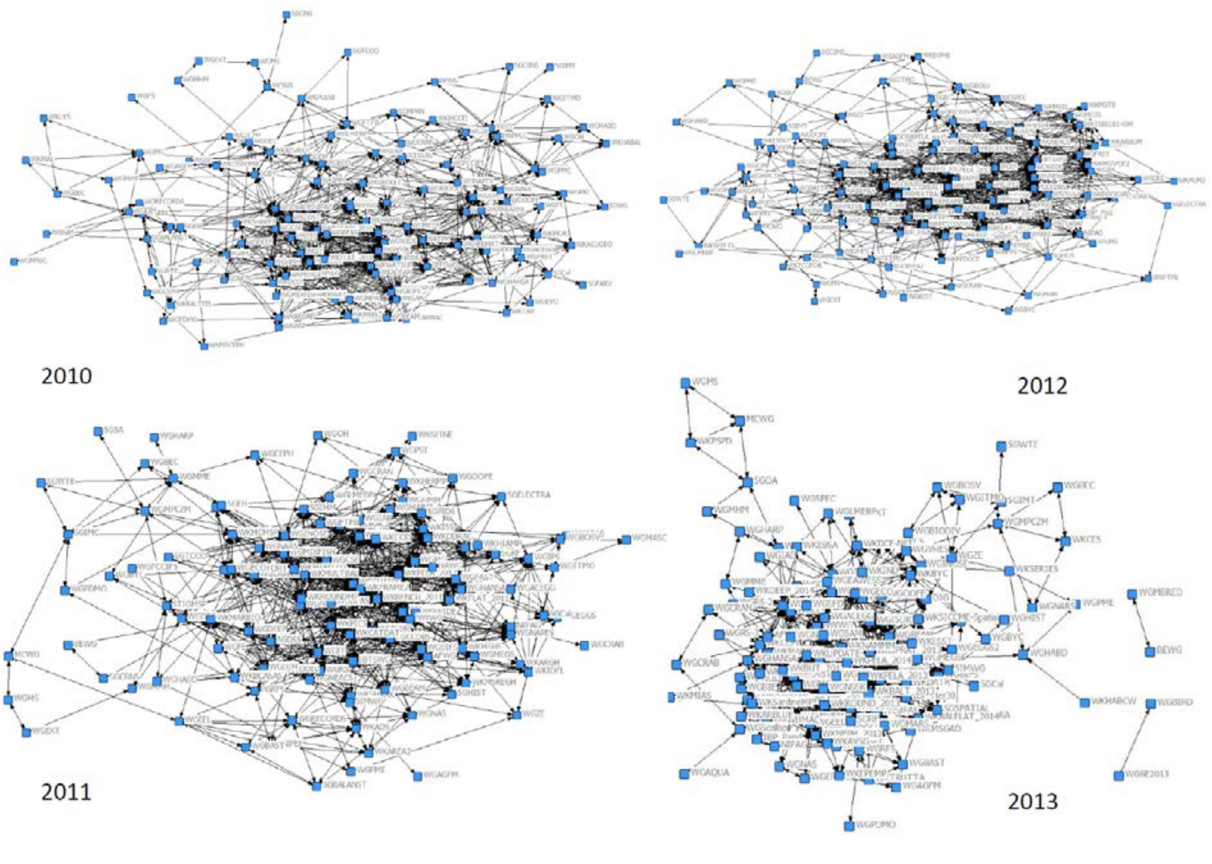

Figure 1: Visualizations of the ICES networks from 2010 to 2013

2 Research questions

During the two weeks research stay at the Stockholm Resilience Centre, different analysis steps were performed to answer the following questions:

1) How are ACOM and SCICOM Expert Groups interrelated?
2) What is the importance of Workshops (WK) in connecting Working Groups (WG) & Study Groups (SGs) within the ICES network?
3) In which way is the ecosystem-based approach (EBA) addressed in the ICES network? Which EGs are required for an EBA for selected ecosystems? Do these networks already exist? Which EGs are not connected? What is the role of the integrated assessment WGs?
4) Which EGs are the major 'hubs' and what is the role of individual EGs in the whole ICES network?

In the following subchapters, we want to discuss the results of the defined research questions.

2.1 The interrelation of ACOM and SCICOM EGs

This analysis step was realized for the 2012 data. We applied a statistical analysis (Join-count statistics) to answer this question. The analysis was similar to the Chi-square independency test. Thus, we were able to compare whether two categorical attributes (ACOM and SCICOM) from a single population (ICES) significantly determined the degree of relationships (the number of links) between and within these two groups.

We anticipated that (i) ACOM EGs would, to a considerable extent, relate to SCICOM EGs through shared membership ties. In this way, one envisions an integration of scientific knowledge in advice. Furthermore, we assumed that shared membership contributes to (knowledge) exchange between different EGs.

Our H_0 was that the inter-group exchange through shared membership was significantly higher than it would have been in a group of randomly distributed links, where node attributes are not considered.

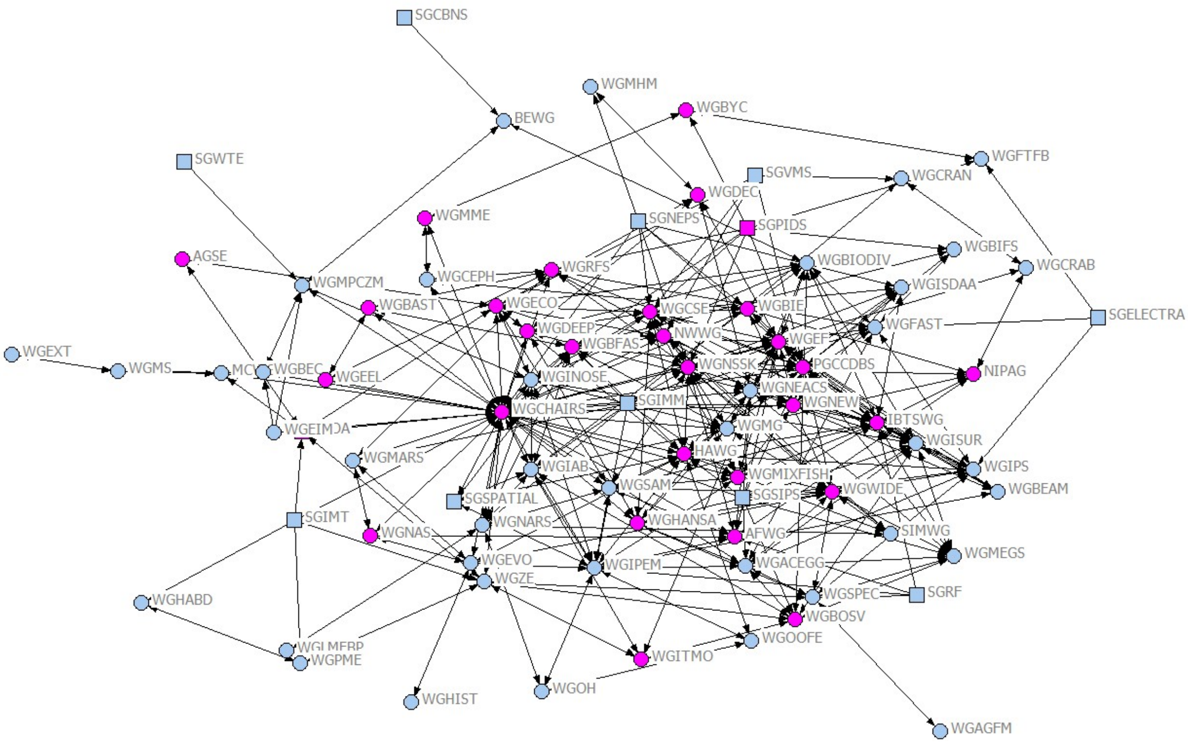

Figure 2: Network map showing ACOM and SCICOM groups without WKs for 2012

Nodes: ICES EGs; Links: shared membership

Colors: pink = ACOM, blue = SCICOM; circles = WGs; squares = SGs

Major statistical results:

Number of iterations = 10,000

Codes:

========

1 = ACOM

2 = SCICOM

	Links/ties	Expected	Observed	Difference	P >= Diff	P <= Diff
1.	1-1	42,949	93,000	50,051	0.000	1.000
2.	1-2	148,101	140,000	-8101	0.815	0.211
3.	2-2	120,949	79,000	-41,949	0.996	0.005

1. The results showed that there was a significant higher rate of shared ties across different ACOM EGs (line 1, 1-1) than expected considering the H_0.

2. The number of shared ties that were observed across SCICOM EGs (line 3, 2-2) was significantly lower than it was expected to be under H_0.

3. There was a slightly lower number of links between ACOM EGs and SCICOM EGs (line 2, 1-2) than it would have been expected.

2.2 The importance of WKs in the ICES network

In order to determine the role of WKs in the ICES network, we applied a two-step analysis. We used network data for 2012. In a first step, we produced a so called two-mode network. This network showed all workshops that connect WGs with each other. It further displayed all WGs and SGs that were connected through WKs. In total, 26 WKs connected 61 different WGs and SGs what is further displayed in the following network map. Only 18 WGs (out of 79) were not connected through WKs.

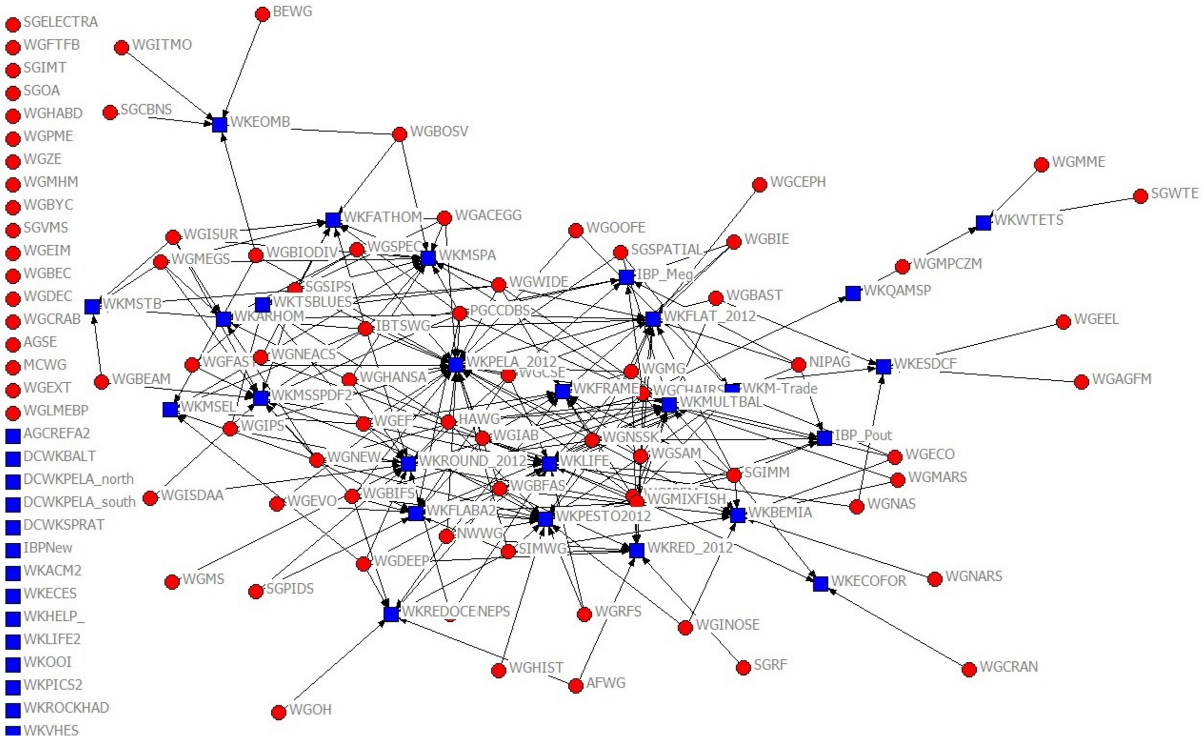

Figure 3: Two-mode network displaying all WKs that are connecting WGs

We further calculated the average network density that was defined as the ratio of the number of ties per node to the number of possible ties (Borgatti, Everett, & Johnson, 2013, pp. 151-152; Jansen, 2006, p. 94; Prell, 2013, pp. 166-167; Scott, 2000, p. 69). Therefore, it measures the overall connectivity of all actors in a network and in this way reflects a higher or lower level of interaction in the form of shared memberships within the ICES network. Density expresses the statistical probability that a tie is existent between any pair of randomly chosen nodes (Borgatti et al., 2013, p. 152). The density in the ICES network considerably rose when including WKs into the analysis. In total 47.8% of possible links between WGs were realized through WKs. This number was very high and reflected the high importance of WKs as an intermediary and connecting variable within the ICES network. Figure 4 illustrates solely the links that were established through WKs. The seemingly complex and vast mass of linkages right in the middle of the ICES network displays the ties that were established through WKs. Therefore, the figure may serve as a good illustration of the role of WKs in the ICES network.

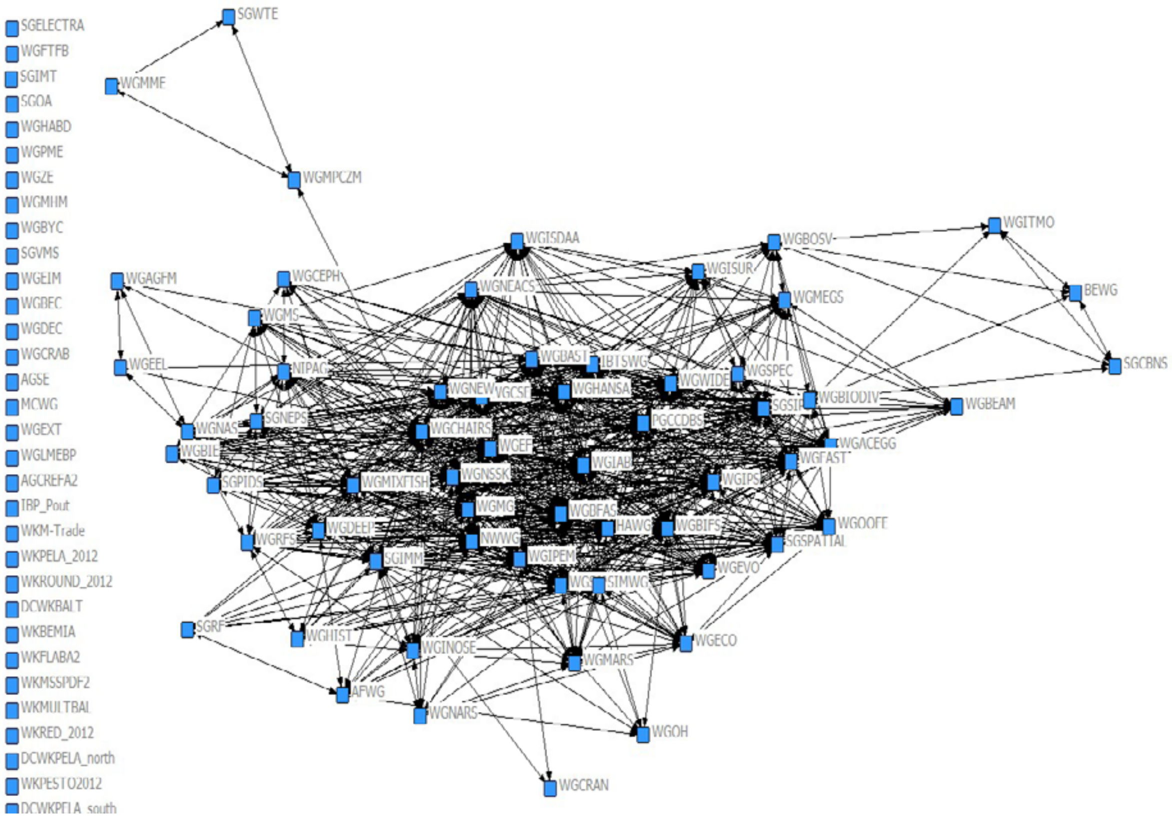

Figure 4: Visualization of those WGs and SGs that are connected through WKs

The following graph shows the network map without WKs. The average density of ties was much lower without the WKs. Only 14.3% of the possible links were realized (compared to 47.8% with WKs).

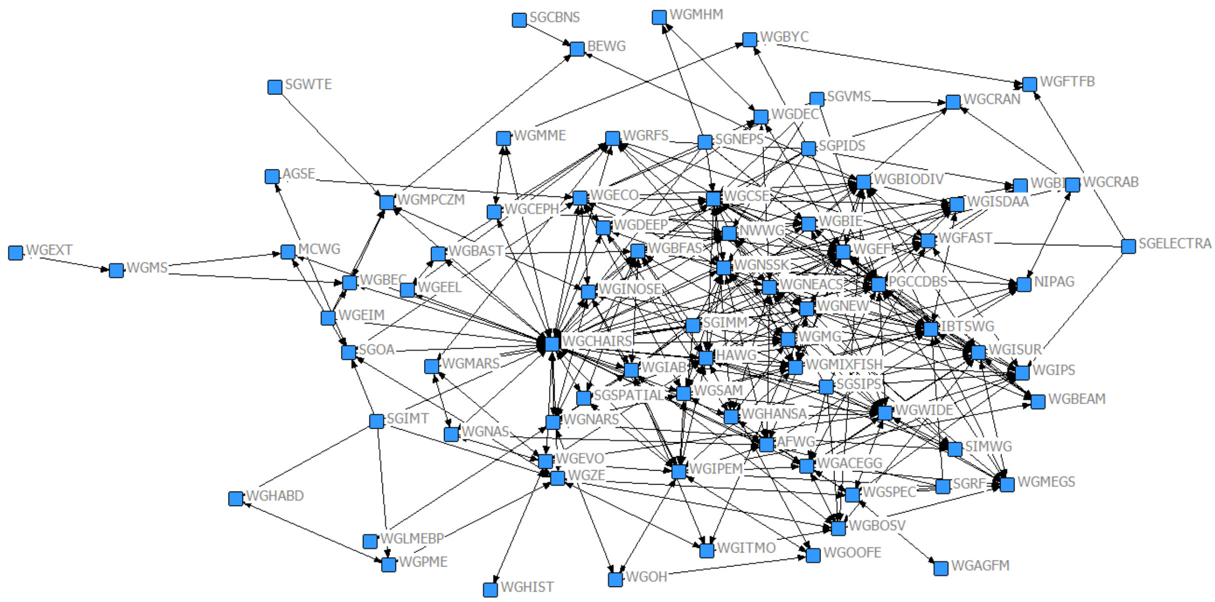

Figure 5: Network map showing ACOM and SCICOM groups without WKs for 2012 (compare figure 2)

2.3 The realization of an ecosystem-based approach (EBA) in the ICES network from a network perspective

Based on expert opinion, we identified those EGs required to implement a regional ecosystem-based approach. Therefore, we selected three case study areas: the Baltic Sea, the North Sea and the Barents Sea. We exemplarily used the network data for 2013. In a first step, we extracted subgroup networks for the case study regions (Figure 6). A statistical analysis was conducted to check, whether the density of ties within and between two groups differed from what would have been expected, if the ties were randomly distributed across all pairs of nodes (Hanneman & Riddle, 2005: Chapter 18). Thus, we were able to assess, whether there was an association between sharing the same attribute (i.e. being a required EG for EBA) and the likelihood of a tie between two EGs. Furthermore, we can predict the number of ties expected in each of the sub-networks and compare them with the observed number of ties to identify the current degree of knowledge exchange. We anticipated that different EGs required for science or advice in an EBA would have more links than randomly drawn EGs.

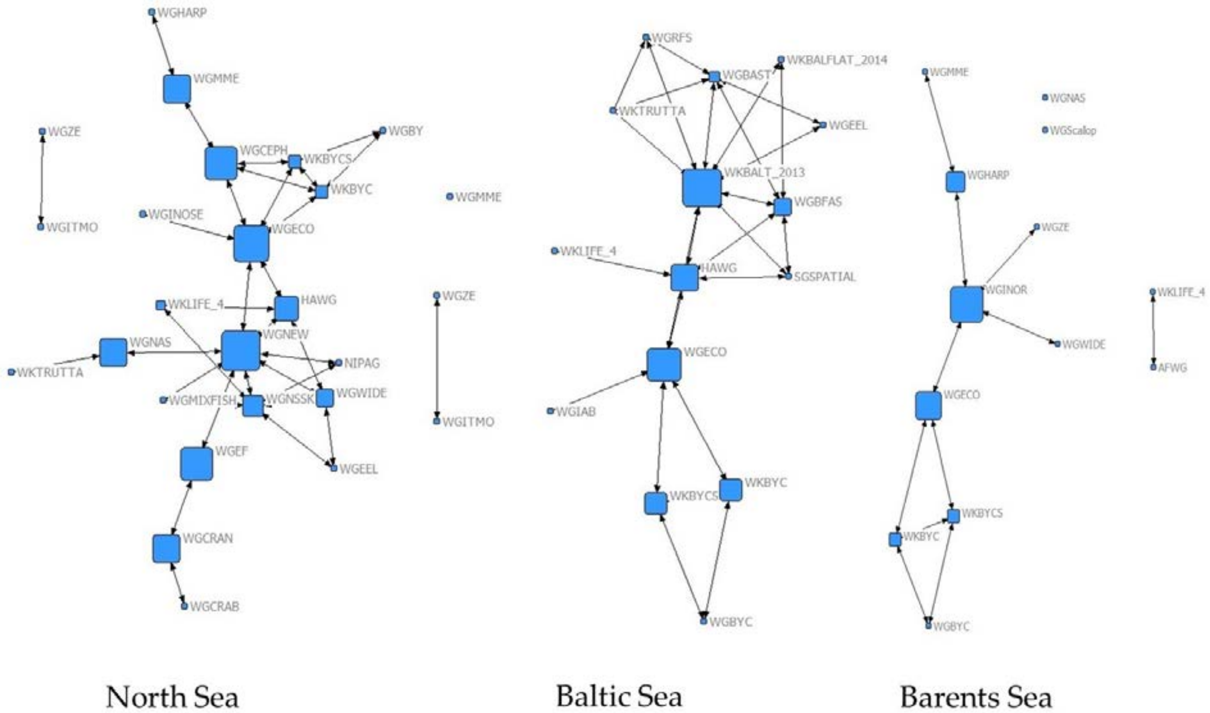

Figure 6: Representations of the connectivity of the expert groups in the ICES network related to three regions: North Sea, Baltic Sea and Barents Sea.

The statistical analysis showed a significant higher intra-group cooperation in all three case studies. Thus, in general, there is a good performance of intra-group exchange and cooperation between these groups. However, the absolute number of linkages between the identified groups that were crucial with respect to an EBA and other groups in the network was lower than it would have been expected. In the case of the Baltic Sea and the North Sea, the integrated assessment groups were marginal within the sub-network, while other EGs played a far more important 'role' in connecting different groups or clusters within the sub-network. In all three sub-networks, there were 'important' EGs that were marginal and not connected to the rest of the network. These EGs did not share members with other EGs.

2.4 Identifying major 'hubs' and 'non-hubs' within the ICES network

This analysis step was based on the following literature and the kindly permission of using 'netcarto' software:

1. Guimera, R., & Amaral, L.A.N., Functional cartography of complex metabolic networks, Nature 433, 895-900 (2005).
2. Guimera, R., & Amaral, L.A.N., Cartography of complex networks: modules and universal roles, J. Stat. Mech.-Theory Exp., art. no. P02001 (2005).
3. Guimera, R., Sales-Pardo, M., & Amaral, L.A.N., Modularity from fluctuations in random graphs and complex networks, Phys. Rev. E70, art. no. 025101 (2004).

In the previous analysis, we have applied typical, standardized methods, in order to assess network structures and structural positions of certain EGs. We further assessed the individual integration of EGs within sub-networks. In the following analysis step, we applied a specifically software to assess the *'role'* of individual groups within the network. Therefore, the implemented mathematical algorithm applies a cluster-based differentiation of EGs within the ICES network. These clusters are called '*modules'* and reflect a group of EGs having been assigned the same role. Guimera/ Amaral 2005 divide between seven different roles (R) that a node might be assigned to (Guimera & Amaral, 2005, p. 897):

R1: Ultra-peripheral nodes (nodes, with all their links within their module)

R2: Peripheral nodes (nodes with most links within their module)

R3: Non-hub connector nodes (nodes with many links to other modules)

R4: Non-hub kinless nodes (nodes with links homogeneously distributed among all nodes)

R5: Provincial hubs (hub node with the vast majority of links within their module)

R6: Connector hubs (hubs with many links to most of the other modules)

R7: Kinless hubs (hubs with links homogeneously distributed among all modules)

<u>Results (for the 2012 data set)</u>

R1 Ultra-peripheral nodes (nodes, with all their links within their module)
AFWG SGRF NIPAG WGCRAB WGNSSK WGSAM IBTSWG WGMIXFISH WGCRAN PGCCDBS WGNEW WGBEAM SGNEPS WGEF WGISDAA WGCSE SGVMS WGBIE

R2 Peripheral nodes (nodes with most links within their module)
SIMWG WGOH HAWG WGOOFE WGIPEM SGSPATIAL SGIMM WGIAB WGINOSE WGMG WGBFAS WGNARS WGLMEBP

R3 Non-hub connector nodes (nodes with many links to other modules)

SGCBNS BEWG WGMPCZM WGEIM WGBEC SGWTE MCWG WGMS WGEXT WGRFS WGBAST WGCHAIRS WGEEL WGCEPH WGMME WGMARS WGNAS WGEVO WGHIST

R5 Provincial hubs (hub node with the vast majority of links within their module)
WGSPEC WGACEGG WGAGFM WGWIDE WGIPS SGSIPS WGHANSA WGBOSV WGBIODIV WGITMO WGISUR WGMEGS NWWG WGNEACS WGDEEP

R6 Kinless hubs (Hubs with links homogeneously distributed among all modules)
SGELECTRA WGFTFB WGFAST WGBIFS WGBYC SGPIDS

R7 Kinless hubs (Hubs with links homogeneously distributed among all modules)
SGIMT WGPME WGHABD WGZE AGSE WGDEC WGECO SGOA WGMHM

The results shown here still have to be discussed in order to derive meaningful interpretations. However, the results illustrate the huge potential of network analysis to discuss different aspects of networks. Thus, besides analyses on structural characteristics, even the different '*roles*' of individuals (or groups) within a network may be identified.

2.5 Linking integrated ecosystem assessment work to benthic work

During the WGMARS meeting in December 2014 in Copenhagen, we had a request from the ICES secretariat to assess how IEA work is linked to benthic work. The results of the study were summarized in the following subchapters. The introduction was taken from the request itself:

'In the ICES region, benthic work is being done through various projects and national initiatives in the Barents Sea, OSPAR and HELCOM regions (i.e. ICG-COBAM, CORESET II, BENTHIS, CAFF-CBMP). Several ICES working groups are also involved with related benthic activities (BEWG, WGDEC, WGMHM, WGSFD, WGECO). ICES is the scientific platform that can contribute towards providing standardized methodologies for benthic community assessments (i.e. D6 seafloor integrity) that ensure comparability and replicability between regions so as to be able to measure progress towards GES.

Good environmental status (GES) for MSFD D6 (seafloor integrity) will be achieved when seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

Benthic communities and associated processes are important elements of marine ecosystems. Changes within the structure and functioning of benthic systems can influence commercially important stocks and ecologically important processes. For example, a large increase in plaice in the North Sea may be associated with concurrent changes in the benthos. A regionally based benthic research plan will be required to understand and predict the ecosystem affects resulting from changes in benthic communities.

As an overarching scientific organization ICES is in a unique position to draw from these scientific communities and provide a regional platform and formalize joint benthic work. Such an initiative would be an important element in implementing ICES Strategic Plan by enabling ICES to draw from a more focused knowledge base on benthic processes essential for integrated assessments by ecoregion.

ICES should strive to regional advice on how to set targets for GES (Good Environmental Status, i.e. targets for sustainable use), thus avoiding conflicting results between regions. An IEA framework can be used to deliver such standards.'

2.5.1 The network analysis

In a first analysis step, the different subgroup networks have been extracted from the overall network. Nodes represent the ICES EGs that had been defined in a previous step to belong to the specified subgroup network. Links represent active EG participants that had been present in at least two different EGs in 2013. Thus, active participants were establishing one link as soon as they were involved in different EGs. We assumed that shared membership ties supported (knowledge) exchange between different EGs.

2.5.1.1 Network map of IEA and benthic EGs

The following network map shows the mutual network of IEA and benthic EGs in 2013 that shared members:

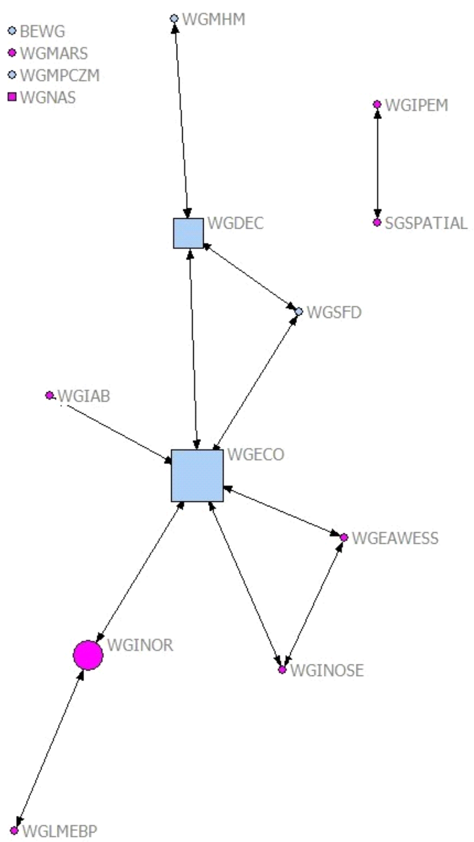

Figure 7: Network map of IEA groups and benthic groups

Legend:

Size of the nodes: Betweenness Centrality

Color of the nodes: Rose: IEA Group
Blue: Benthic Group

Shape of the nodes: Square: ACOM
Circle: SCICOM

Definition 'Betweenness Centrality':

Betweenness centrality defines the degree to what extant an individual actor connects other actors in the network that would otherwise not be linked (Burt, 1992, p. 74). Thus, it quantifies the number of times a node bridges along the shortest or geodesic path between two other nodes (Freeman, 1979, p. 221; Wasserman & Faust, 1994, p. 44). It thus requires an actor to occupy an intermediary position (Prell, 2013, p. 104).

2.5.1.2 Network map of Benthic EGs in 2013

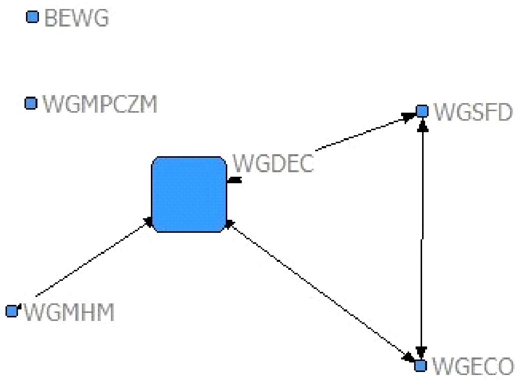

Figure 8: Network map of ICES Benthic EGs in 2013

2.5.1.3 Statistical analysis of intra and inter-group exchange

In this analysis step, we conducted a statistical test checking whether the density of ties within and between two groups differed from what would have been expected, if the ties were randomly distributed across all pairs of nodes (Hanneman & Riddle, 2005: Chapter 18). Thus, we were able to assess, whether there was an association between sharing the same attribute (i.e. being a SSGIEA or Benthic group) and the likelihood of a tie between two EGs. Furthermore, we predicted the number of ties expected in each of the sub-networks and compared them with the observed number of ties to identify the current degree of (knowledge) exchange.

Major statistical results:

Number of iterations = 10,000

Code
========
1 = neither IEA nor benthic group
2 = IEA or benthic group

	Links/ties	Expected	Observed	Difference	P >= Diff	P <= Diff
1.	1-1	547,543	596,000	48,457	0.035	0.969
2.	1-2	142,837	92,000	-50,837	0.987	0.016
3.	2-2	8619	11,000	2381	0.283	0.783

1. The results attested a significant higher rate of exchange between EGs that were neither IEA nor benthic groups (line 1, 1-1).

2. There was a significant lower rate of exchange than expected between those groups not defined as IEA or benthic groups and those that belonged to the defined subgroup network including exclusively IEA or benthic groups (line 2, 1-2).

3. There was a slightly higher exchange than expected between EGs that were defined as IEA or benthic groups (line 3, 2-2). However, this result was not statistically significant.

3 Outlook

In December 2014, 15 qualitative interviews were realized with members of ACOM and SCICOM in order to complement the quantitative network data with qualitative data. The combination of different methodological approaches serves as an important source to validate and understand the visualized networks and the reasons and consequences of different network constellations. The evaluation of the interviews will be one of the major foci in the next working phase. The interviews emphasized the individual perceptions of structural strengths of ICES and challenges with respect to future responsibilities and tasks. We would further like to expand the time series of the analysis and include network data from 2014 to understand network dynamics and to identify stable and dynamic patterns within the network structure.

4 Literature

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