

WebPanel 1. Defining the high-performing team

Many scientists use the terms “groups” and “teams” interchangeably. However, groups are often hierarchical in structure, with one strong leader who makes many of the decisions for the group and delegates responsibilities (Katzenbach and Smith 1993). In contrast, teams have shared or distributed leadership, resulting in more collective outcomes that are a result of members making decisions and working together to achieve mutual goals (Katzenbach and Smith 1993); for this paper, we use the latter term and definition.

Teams can be arranged along a gradient of performance level that measures the outcomes of team functioning (Figure 1). At the lowest performing level are pseudo-teams, in which the outcomes are lesser than what individual members might have anticipated accomplishing on their own. Such teams are composed of members with little training or interest in working in a team, who perceive competition within the team, and who see little need for working as a team. “Pseudo-teams” hinder performance and achieve only to the level of the lowest-performing member. In imbalanced teams, performance level is not hindered, but does not exceed that of the highest performing team member (Figure 1). In contrast, high-performing and highest-performing collaborative research teams are made up of diverse members with complementary skills and perspectives. These teams are committed to a common purpose, performance goals, and approaches, and they hold themselves, individually and mutually, accountable (Figure 1; Katzenbach and Smith 1993; Smith and Imbrie 2007). Members of these teams work together to achieve mutually held, high standards for work quality, and they provide support based on shared personal and professional commitments. Team members are committed to learning interpersonal skills for effective communication, decision-making, problem solving, conflict management, and leadership, and are expected to practice and use these skills throughout the collaboration. These teams also undergo periodic, candid group processing during which the team reflects on how well it is functioning, acknowledges what is going well, and corrects what is not going well. As a result, high-performing collaborative research teams are able to successfully work on very complex problems and achieve high levels of productivity. The rarest type of research team is the “highest-performing collaborative research team” that outperforms any reasonable expectations in meeting team goals, solely because of an exceptionally high commitment of all members to each other and the team’s success (Figure 1; Katzenbach and Smith 1993; Smith and Imbrie 2007).

WebPanel 2. Teamwork exercises

Below are some examples of teamwork exercises that help develop understanding of and appreciation for team diversity, build interpersonal skills, and work on team communication and functioning. The numbering is as for Figure 2. It is recommended that early in a team's life, exercises that develop social sensitivity and emotional engagement occur first; these will facilitate the later exercises on team communication and functioning. The exercises for diversity and social sensitivity are combined because most exercises that deal with either of those characteristics also deal with the other.

1–2. Diversity and social sensitivity

The use of these tools helps to promote a deeper understanding of and appreciation for the diversity of team members present, including fundamental differences in personality, learning styles, and philosophies. An open discussion and exploration of the range of perspectives present in a team helps to develop each individual's social sensitivity (Figure 2).

- Personality type
eg Myers-Briggs Type Indicator (www.myersbriggs.org/), Strengths-Finder (Buckingham and Clifton 2001), Enneagram personality test (www.enneagraminstitute.com/)
- Learning style
eg Learning style instruments (Coffield *et al.* 2004)
- Philosophical underpinnings or conceptual schemes
eg Toolbox for philosophical dialogue (Eigenbrode *et al.* 2007)
- Points of view, perspectives, backgrounds
eg Diversity letter game (http://imarketingsolutions.com/diversityresources/rc_sample/ice2.html)

3. Emotional engagement

These exercises and activities help to facilitate emotional engagement among team members and with the project (ie the personal and professional commitment that are very important for overall team functioning and communication; Figure 2).

- Ice-breakers with sharing of personal facts
(eg WebSupplement 2)
- Activity related to excitement about team project
(eg WebSupplement 2)
- Non-work team activity
(eg kayaking, hiking, dining, attending an event, contributing to a service project)

4–5. Team functioning and communication

- Communication
eg physical room setup, critical listening skills, promoting equal contributions among participants (WebSupplement 3)
- Idea generation
eg brainstorming (WebSupplement 2)
- Problem solving/decision making
eg “They’ll never take us alive!” (Smith and Imbrie 2007), discussion of case studies
- Conflict management
eg “How I act in conflict” (Smith and Imbrie 2007), discussion of case studies (WebSupplement 4)
- Individual and team time management
eg WebSupplement 5
- Establishing team norms
eg team charters and contracts (eg Smith and Imbrie 2007; WebSupplement 6)

WebPanel 3. Embracing cultural diversity in an international grassroots network

Global challenges, such as the availability and quality of fresh water, are demanding unprecedented collaboration by the international scientific community. In the Global Lake Ecological Observatory Network (GLEON.org), members from more than 40 countries meet annually to set a global science agenda and form teams to accomplish those goals (WebFigure 1). GLEON members share the outcomes through publications, workshops, outreach, and training activities. Week-long annual “All Hands” meetings are hosted by a different member site each year (US or abroad). Members meet to share scientific research, lead and engage in training sessions, continue existing projects, and embark on new collaborations. The process of doing science occasionally creates tensions derived in part from GLEON member disciplinary or geographic cultural differences. Member interaction strategies, including personal communication styles, research engagement approaches, hierarchical navigation, and data ownership and intellectual property perspectives vary tremendously among cultures. Over the course of 15 annual meetings, GLEON has recognized that overcoming these “people network” challenges requires member adoption of basic rules for successful collaboration. These rules acknowledge and accommodate the roots of science as well as basic human needs, such as to be: invited to participate, recognized for one’s contributions, accepted for whom one is, and given a voice in guiding the future of the network. GLEON’s continuous effort to recognize and resolve these challenges shapes the network mission and operating principals, as well as the mechanisms by which they collaborate remotely between meetings and the meeting format itself. GLEON is a learning organization and its model is not static: they adapt their activities, habits, and culture as the network evolves.

Acting on a set of principles: Governance in GLEON is meant to reflect the diversity of the network, and provides leadership opportunities to willing members at all career stages. Governance is guided by GLEON’s Operating Principles and Procedures (www.gleon.org/Leadership_and_Governance.php) that “express the rules of operation as a form of technical and scientific international cooperation”. There, they distill and formalize GLEON’s culture and ethos into ten core values. Below, we highlight three of these values and describe some of the mechanisms by which they are applied in practice to enhance activities of this international grassroots network.

(1) Participation: *GLEON members value collegiality, mutual respect, collaboration, and involvement among researchers from various disciplines.*

In action: Barriers to participation in GLEON meetings are greatly reduced by using multiple communication modes, providing facilitation training, making leadership opportunities available for all members, and recognizing that diversity contributes to creative and robust outcomes.

(2) Openness: *GLEON members provide guidance and share experiences and expertise openly, freely, and willingly.*

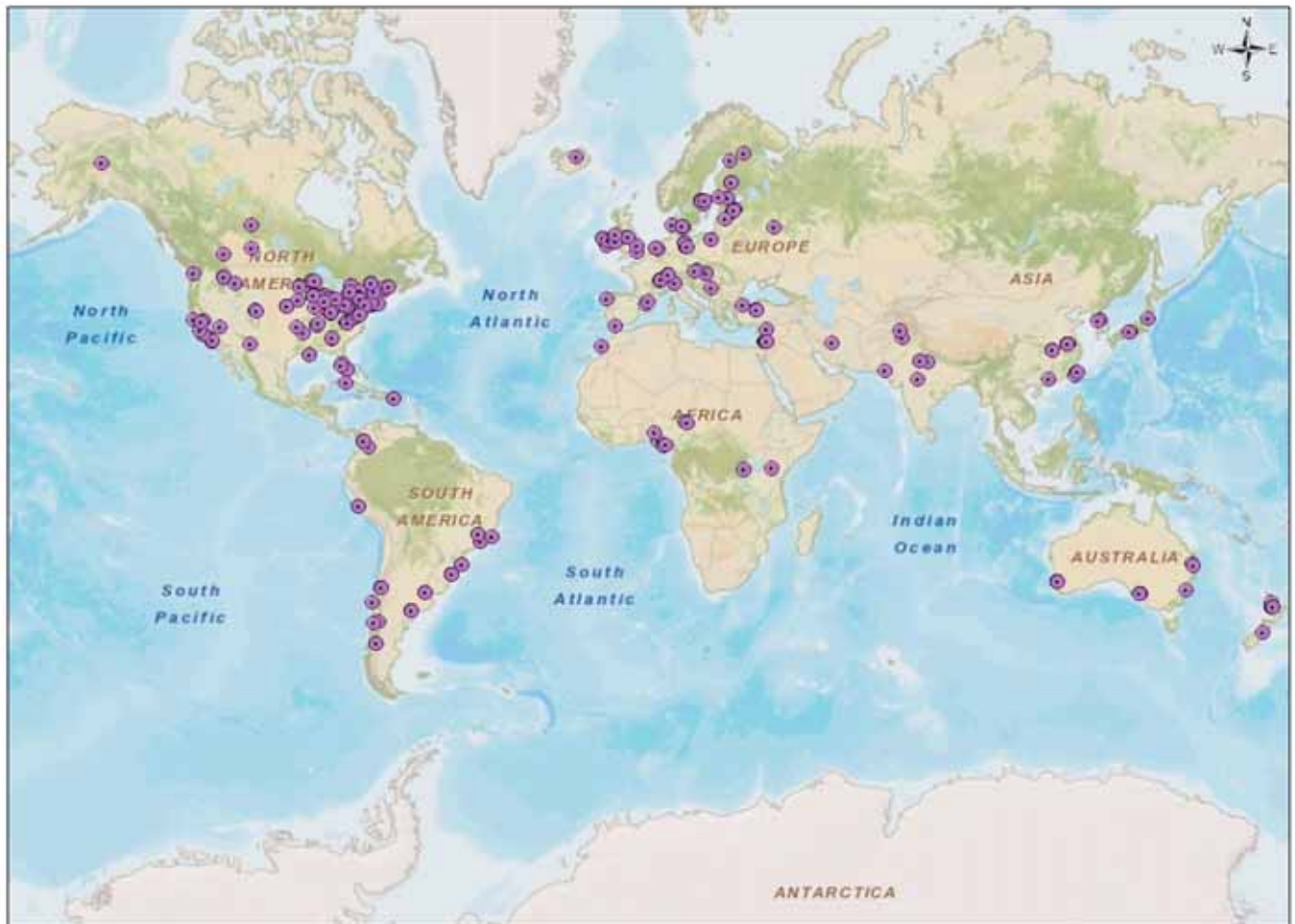
In action: Shared learning environments that have transparent processes are core to GLEON, and include member-led open working groups, a technology listserv (http://maillist.gleonrcn.org/pipermail/gleontech_maillist.gleonrcn.org/), pre-meeting workshops (www.gleon.org/Science-Technology.php), ad-hoc training sessions, and traditional oral and poster research presentations during All Hands meetings.

(3) Informality: *GLEON members maintain informality when conducting business.*

In action: Subtle, but important features of GLEON All Hands meetings are that they are designed to be interactive, non-hierarchical, and collegial. GLEON has found that mentoring, encouraging, and empowering students and early career scientists to embrace leadership positions, as well as employing world café-style discussions, increases the ease of the experience and interactions between members from a range of geographic, cultural, age, gender, and professional backgrounds. The vast majority of All Hands meeting participants say that the meetings have: (a) exceeded their expectations, (b) resulted in new contacts, and (c) made them likely to attend a subsequent meeting (GLEON assessment data not shown).

WebPanel 4. Author contributions

The paper was conceived of and outlined by KSC and PAS. They co-led a workshop for their research team during summer 2011 that used many of the teamwork exercises described herein and that were originally developed or adapted by KSC. The paper was further defined by conversations among KSC, PAS, KCW, PCH, and SG (and others) while writing Goring *et al.* (2014). KSC coordinated the writing and revision of the manuscript and wrote the abstract, WebPanel 1, the “Building the culture and interpersonal skills of high-performing collaborative research teams” and “Maintaining the team culture: team assessment” sections. PAS and KSC wrote the introduction and “in a nutshell” sections. PAS wrote the “Creating high-performing collaborative research teams”, “Needs for future high-performing collaborative research teams”, and “Conclusion” sections. KSC wrote WebSupplements 1–6, and CTF and KSC wrote WebSupplement 7. KCW and PCH contributed the science of team science perspective in the paper. KCW, PCH, and EKR wrote WebPanel 3. PAS drafted the table and figures. All co-authors performed critical reviews and improved the manuscript prior to submission.



WebFigure 1. Home institutions of GLEON's 390 members, including ~130 students.

WebSupplement 1: Overview of WebSupplements 2–7 – guidelines for using teamwork exercises, drafting team policies, and assessing team functioning

WebSupplements 2–5 can serve as a model for how to implement a series of teamwork exercises. WebSupplement 6 provides examples of team policies about important team practices such as data sharing and co-authorship, and WebSupplement 7 provides guidance on assessing team functioning.

For implementing teamwork exercises (WebSupplements 2–5), consider a new team with members who are at different institutions, some of whom have never met, and that a 4-day workshop of all members is planned very early in the project. An effective strategy can be to kick off each day with teamwork exercises. Given the importance of the first day, the first exercise we present (WebSupplement 2) takes 3 hours, but most others (WebSupplements 3–5) take roughly one hour each. The order of the activities is important, in that more complex and potentially contentious issues are saved for later days once the team members have gotten to know each other and have established trust.

In addition to formal teamwork exercises, it is important to include some more informal and social activities during the team's time together (eg group outdoor activities such as kayaking, hiking, skiing; meals with socializing; game nights; happy hours, eg Figure 4). For example, SG received this feedback after conducting an informal teamwork activity that included mimicking historical data collection, "Getting the Settlement Vegetation team out to survey the original Public Land Survey points was great. It gave us an opportunity to do some science together in a fun and relaxed atmosphere. Given that we draw on a broad range of disciplinary backgrounds, it helped us come together to understand some of the methodological issues with the data, and helped us visualize the dramatic changes in forest cover that we've seen over the last 150 years".

The balance of more formal and facilitated teamwork exercises and informal social activities will depend on the team composition and needs, such as the proportion of brokers, incumbent members, etc. (Figure 3). Although KSC and PAS used the particular exercises described in WebSupplements 2–5 soon after creating a new team, we believe that it is important for team functioning to build upon such exercises throughout the duration of the team, especially because the team's goals and membership change through time.

These (and other) teamwork exercises feed into the establishment of explicit standards about behavior (ie team norms) that establish clear expectations among team members, increase trust and maximize benefits for all team members, and thus increase research team functioning and productivity. One outcome of the establishment of such norms can be a set of team policies about important practices such as data sharing and co-authorship. Therefore, WebSupplement 6 includes examples of some important team policies that KSC and PAS have developed and implemented in their research team and that we argue should be developed collectively by the team. It is important to remember that these policies are living documents that change over time to reflect changing team membership and project goals. Finally, because assessment of team functioning is integral for maintaining a high-performing team (eg Smith and Imbrie 2007), we end with an example of a survey instrument that could be administered at a second workshop or remotely to determine how well a team is functioning to meet both individual team member's needs and the entire team's goals (WebSupplement 7).

Suggested strategy for implementing teamwork exercises and increasing team functioning at a 4-day workshop:

- Agenda distributed prior to the workshop. Allow 1 week for homework preparation and remind the group prior to travel day.
- All but the first day's teamwork exercises are scheduled for an hour.
- All facilitators meet/talk before the workshop to ensure that they are all on the same page about the importance and the goals of each activity, how each activity should be facilitated, and how to navigate potential issues that might emerge during each activity.
- Each half-day, a new person is charged with writing minutes – careful attention to ensuring that a variety of male/female members across all career stages are asked to take minutes.
- Use file-sharing software such as Dropbox or Google docs to share files during the meeting (Wi-Fi needs to be available).
- Each of the exercises should have a facilitator or two, who direct(s) the activity, say(s) a few words at the beginning about the goal(s) of the exercise, give(s) background provided in the referenced documents, and synthesize(s) or debriefs the activity at the end.
- Note that although we have described the following teamwork exercises as a series that build upon each other (and have found that extremely productive for increasing team functioning), individual exercises can be used without the others.
- Group composition: Make small groups of 4 people (better than groups of 3 that can end up with one less engaged member) in advance, and change them every day so that different people interact each day during the team-building sessions.
- Room set-up: Pay close attention to physical space. Carefully arrange comfortable seating and ask team members to change where and who they sit next to frequently. This approach is important because research has shown that small groups will arrange themselves in a hierarchical way, and then discussions will be uneven (De Long 1970). For example, in some of the WebSupplements, we suggest setting up chairs in a U-shape. Without any intervention, the leader is likely to sit in the middle spot, with the most dominant team members arranging themselves in a descending fashion on both sides of the leader, leaving the end spots for the least dominant (and most quiet) members (De Long 1970).
- Expect some push-back from team members. Some scientists will resent spending time on what they deem as "non-science activities". However, as the culture of science evolves to include and value non-disciplinary skills as necessary and important for scientific success, this resistance should lessen. Keep in mind that push back is a normal reaction to going outside one's comfort zone, and can be a direct response to learning and experiencing new things. Therefore, some level of resistance is good ("teams must storm before they can norm").

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WebSupplement 2*: Day 1 – Project team-building

*[*This supplement is written as instructions to the facilitator(s) running the teamwork exercises]*

Goal

To promote (a) individual emotional engagement with both the team and the project (b) appreciation for team diversity.

Rationale

Team-building activities that increase emotional engagement and understanding of and appreciation for team diversity (WebPanel 2) can help members get to know one another, appreciate similarities and differences in points of view, and build emotional engagement and social sensitivity, thus generally increasing interpersonal skills (Figure 2). The choice of activity is particularly important, and the location and format of such exercises can play a role in their effectiveness. For example, face-to-face activities held outside of normal work locations and that stimulate conversations about both personal and professional topics can successfully start, build, and maintain the kind of personal and professional bonds that are necessary for high- and highest-performing collaborative research teams (WebPanel 1). Using these activities when a team first forms is essential, and can nicely lead into discussions of individual and team expectations, goals, and needs. However, in recognition of the fact that team membership and project goals evolve, we emphasize that implementing these types of activities throughout the lifetime of the team is important to stay “high performing”.

Context

KSC and PAS used this exercise to kick off the first day of a 4-day face-to-face workshop of a newly formed, interdisciplinary team that had a mix of team members, some of whom knew each other and some who did not. See WebSupplement 1 for general suggestions for how to effectively use these (and other) teamwork exercises.

Exercise Resources

- Poster-sized world map taped to front wall
- 4 × 6 cards, each with a project participant’s picture on it, name, place of employment, and discipline. Depending on team make-up, you can also color-code the 4 × 6 cards according to career stage (or other demographic characteristic you want to emphasize)
- Table-top flip charts for each small group, markers, tape
- Two rooms – one set up with tables in a U-shape facing the front wall, and other with small tables for small group discussions. Alternatively, the room needs to have movable tables so that the layout can be re-configured as needed.

Setting the Stage

Facilitator welcomes participants to the working meeting, presents the agenda for the day and week (that has been emailed to them previously), and asks everyone to disable Wi-Fi and turn off their phones until the first break. Facilitator talks very generally about the various roles participants play in the project, the different career goals and career stages represented, and the variety of strengths, skills, and perspectives that the participants bring to the table. They then introduce the exercise – “one way that teams can best function to ensure high productivity is by everyone being emotionally engaged and both personally and professionally committed to the project and to each other. Thus, we engage in this team-building exercise.”

Step-by-step instructions (approximate time, ≥ 3 hrs; works on emotional engagement)

Part 1: Getting to know each other [~75 minutes for 15–20 participants] (works on emotional engagement among team members)

1. The room should be set up in a U-shape, facing one wall with the map on it.

2. After setting the stage (above), facilitators pass out the 4 × 6 cards
3. Everyone writes answers on the card to the questions below (a–c),
 - a. What name would you like to be called by?
 - b. From memory, what was your favorite childhood toy and why?
 - c. What is either your favorite lake or the lake you hope to visit someday (if money were no object), and why? [Note: This question can be adapted to fit whatever project topic you are working on – much of the focus of our project is on lakes, but you could substitute any ecosystem.]
4. One by one, participants stand at the front of the room and share a–c answers with the group, then tapes their 4 × 6 card to the map on the wall near the location described in (c). Alternatively, participants can pair off with someone they have never met, interview that person to get answers to 3a–3c, and then take turns introducing their partner to the rest of the team. This latter approach may be most useful for teams with fewer incumbents, with many students, or with people from multiple nations.

Part 2: Revisiting the project [60 minutes in small groups] (works on emotional engagement with the project)

1. Prior to the working meeting, ask the participants to re-read the project proposal and reviewer comments, and then answer the following 4 questions (a–d):
 - a. What part of the project do you find most interesting/compelling (what part do you most want to be part of?)?
 - b. What is the most potentially transformative aspect of this project (and, transformative to what, and why?)?
 - c. What do you see as the most challenging aspect of this project (and why?)?
 - d. Which constructive comments from the reviewers should be integrated into our project plan (and how?)?
2. The groups should go to a room set up for small group discussions, or the room needs to be reconfigured for small group discussions.
3. Facilitators ask participants to move into the pre-assigned groups of 3–4 participants each. These groups are designed ahead of time to increase diversity of perspectives during this portion of the meeting. Composition can vary depending on the project and team, but ideas for promoting diversity in small groups include forming heterogeneous groups by discipline, career stage (but, students should not be outnumbered), or demographic characteristics (without outnumbering minorities [broadly defined]).
4. Facilitators instruct the groups to discuss the answers to all 4 questions in their small groups, being sure that: each person speaks about each of the 4 questions, each of the 4 questions is discussed relatively equally, and someone takes notes on the discussion on a flip chart. Facilitator can assign roles for each group (facilitator, time keeper, note taker) or tell the groups to do this on their own during the first 2 minutes. The note taker in each group synthesizes the answers to the first three questions (a–c) into major bullet points on a flipchart.

Part 3: Synthesis – Compiling project lists: interests, transformative aspects of the project, challenging aspects of the project [60 minutes – entire team] (continues the emotional engagement with the project)

1. Each of the above groups reports the bullet points from (4) above to the entire project team. During the presentations, the facilitator records major points on 3 flip chart sheets (one for each question a–c), using check or tally marks to indicate duplicate answers across all of the small groups to identify common themes.

2. Facilitator collects lists of answers to (d) and adds them to the meeting minutes for the day.
3. Facilitator revisits these lists, adding new ideas and prioritizing them, on each of the remaining days of the workshop.

WebSupplement 3*: Day 2 – Increasing the effectiveness of individual and team communication skills

*[*This supplement is written as instructions to the facilitator(s) running the teamwork exercises]*

Goal

To promote effective communication skills.

Rationale

Effective communication, and especially critical listening skills, are essential for high-performing collaborative research teams (Smith and Imbrie 2007; WebPanel 1). Research has demonstrated that lack of dominance of any one member, equal interactions among all members, open and encouraging body language by all members, and individuals' tone of voice are all more important for predicting team productivity than the content of the communication (Pentland 2012; Figure 2). Research also demonstrates the importance of face-to-face communication (eg Hinds and Bailey 2003; Hampton and Parker 2011). However, fostering skills that promote effective communication in broad, interdisciplinary, multi-institutional teams can be difficult. Therefore, in WebPanel 2 and below, we provide some example activities that can build critical communication skills and a list of some technological resources that can simulate the necessary face-to-face interactions for teams (WebTable 1).

Context

KSC and PAS used this exercise on day 2 of the first 4-day face-to-face workshop of a newly formed interdisciplinary team that had a mix of team members, some who knew each other and some who did not. See WebSupplement 1 for general suggestions for how to effectively use these (and other) teamwork exercises and WebSupplement 2 for day 1's team-building exercise.

Exercise Resources

- Handout of constructive and destructive group behaviors (at the end of this supplement)
- Handout of pages 40–41 of Smith and Imbrie (2007) about communication
- Two rooms – one set up with tables in a U-shape facing the front wall, and another with small tables for small group discussions. Alternatively, the room needs to have movable tables so that it can be reconfigured as needed.

Setting the Stage

Facilitator welcomes participants to the working meeting, presents the agenda for the day, and asks everyone to disable Wi-Fi and turn off their phones until the first break. On the basis of the discussions from the previous day, the facilitator summarizes the various roles participants play in the project, the different career goals and career stages represented, and the variety of strengths, skills, and perspectives that the participants bring to the table. They then introduce the exercise by talking about the importance of everyone learning and practicing communication skills, such as critical listening, for best team functioning and productivity.

Step-by-step instructions: (approximate time, 1 hr; works on team communication skills)

Part 1: Team behaviors and communication [~20 minutes for 15–20 participants in small groups]

1. The team should be in the room set up for small group discussions, or the room needs to be reconfigured for small group discussions.
2. Facilitator asks participants to move into pre-assigned groups of 3–4 participants each. These groups are designated ahead of time to increase diversity of perspectives during this portion of the meeting. Composition can vary depending on the project and team, but ideas for promoting diversity in small groups include forming

heterogeneous groups by discipline, career stage (but, students should not be outnumbered), or demographic characteristics (without outnumbering minorities [broadly defined]).

3. Facilitator passes out handout about constructive and destructive group behaviors and instructs members to read the sheet before starting small group discussions.

4. Facilitator instructs the groups to discuss the elements of effective communication (ie what are the characteristics of effective communicators?), being sure that each person speaks and that someone takes notes of the discussion on a flip chart. Facilitator can assign roles for each group (facilitator, time keeper, note taker) or tell the groups to do this on their own during the first 2 minutes. Note: facilitator can even go so far as to provide a way for the small groups to ensure even interaction among individuals such as providing an even number of coins, marbles, or the like to each individual that represent the number of times each person should speak during the conversation. Such strategies help people think before they speak and to notice that individuals may not be contributing equally to the conversation. Use of such a strategy also helps a facilitator who may feel uncomfortable about, or have a difficult time, controlling dominant people.

Part 2: Team behaviors and communication [~20 minutes for 15–20 participants in small groups]

1. Facilitator passes out the handout from Smith and Imbrie (2007) about communication and instructs members to read it.

2. Facilitator instructs the small groups to discuss the short reading and revise their list of elements of effective communication (on flip chart), based on this additional information.

Part 3: Synthesis – Compiling effective communication characteristics [~20 minutes – for 15–20 participants working together as entire team]

1. Each of the above groups reports their list of characteristics from above to the entire project team. During the presentations, the facilitator compiles a master list of effective communication elements by recording major points on a flip chart sheet and using check or tally marks to indicate duplicate answers across all of the small groups to identify common themes.

2. Facilitator should make sure that this master list includes aspects such as lack of dominance by any one member, equal interactions among all members, members' open and encouraging body language, and members' tone of voice, and shares with the team that research shows that these aspects of communication are more important than the content of communication for predicting team productivity.

Additional information on this topic:

On the basis of research results (Pentland 2012), we know that face-to-face communication is most effective. However, many ecology, and especially macrosystems ecology, projects are multi-institutional. Therefore, in WebTable 1 we provide some information on ways to use technology to simulate face-to-face communication or enhance long-distance project communication and information/data-sharing.

For multinational teams, communication issues that are related to differences in language, customs, and power structures can be particularly challenging. Solutions should be based on the philosophy that international partners are integral members of the team, and therefore should share in the responsibilities, decision making, and communications of the team. Effective multinational communication requires careful thought and appropriate structure. For example, email communication (in English) with non-native English speakers is often extremely time consuming to read and respond to; technologies such as some of those in WebTable 1 below may be more effective (eg Skype with video).

Although many of the tips we provide for effective communication within multinational teams have analogs for national teams, these strategies may be particularly important when there are additional dimensions of diversity on a team –

those of nationality, culture, and language. Having multiple modes of communication is important for multinational teams with multiple native languages. In addition to verbal communication, teams should provide team members handouts with key figures, tables, ideas and phrases far enough before the meeting so that translations can be made if necessary. When talking, teammates need to slow down and provide sufficient pauses and breaks for non-native English speakers to crosscheck terminology in their native languages. Distributing leadership, presentation, and facilitation roles will give others a chance to set the pace of discussion and increase their visibility, as well as help everyone on the team remain aware of the diversity present. It is important that all nations are represented in the governance structure of the team and that frequent communication occurs regarding the principles of the organization to set the expectations for team standards of behavior (ie team norms) such as breaking-down power structures, providing credit for diverse contributions, and distributing leadership opportunities. Finally, as with all teams, the efficacy of these approaches must be assessed in multiple ways and the assessment results openly discussed in terms of the successful and not so successful strategies for overcoming the particular challenges faced by multinational teams.

WebTable 1. Some Web-based tools for collaborative groups

Below we describe the major categories of tools available online to facilitate communication and sharing of collaborative groups that contain members who are not all housed at one institution. There are many services available, some free, some free until a file storage limit is reached, and some are for-pay from the beginning. Although these tools are especially important for teams with members that are distributed in space, they are also relevant for groups at the same institution (ie file storage and sharing). One place that is compiling many of the available online tools for collaboration is Mind Meister

(www.mindmeister.com/12213323/best-online-collaboration-tools-2012-robin-good-s-collaborative-map).

File storage and sharing – Allows groups of people to access files stored digitally, typically in a central location, either online, on a server, or through peer-to-peer networking. A few examples are:

Dropbox	BitTorrent/Share
Google-drive	CloudStor
Google EC2/Glacier	

Organizing and sharing of research literature – Facilitates the sharing of research literature in the form of PDF documents, citation sources, etc. A central depository for research teams facilitate the sharing of knowledge and ideas from the literature. A few examples are:

EndNote Web	Zotero
RefWorks	Mendeley

Online document editing – Online document editing is different than file sharing in that files can be accessed and edited simultaneously by multiple people at different computers (and institutions). Many services provide version-control functionality.

Google-docs/drive	Subversion
Zoho Docs	Adobe Buzzword

Audio and video conferencing – Enables conference calling with audio or audio and video among two or more participants. The options range from the very simple to the more complex, with sharing of a range of audio-visual content, chat-room features, etc.

Skype	Ekiga	FaceTime
Google Hangouts	Adobe Connect	Elluminate
Big Blue Button	Moodle	WebEx
ooVoo	MegaMeeting	GoToMeeting/GoToWebinar
DimDim/salesforce	Vidyo	

Online collaboration platforms – Helps team members work together on projects. Such software includes a variety of different features to facilitate communication, file sharing and work including, but not restricted to: chat-rooms, group calendars, email-type communication within the team, file-sharing, time management tools. There are many options in this area that range from very simple to very complex, integrated platforms.

Centraldesktop	projectkino	Sharepoint
MyExperiment Central Desktop	Adobe Buzzword	Microsoft Office Live
hubzero	Teamness	Labmeeting
Huddle	Confluence (atlassian)	Podio
Wiggio	EVO	

CONSTRUCTIVE AND DESTRUCTIVE GROUP BEHAVIORS

From: Brunt J. 1993. Facilitation skills for quality improvement. Quality Enhancement Strategies. Madison, WI.

Constructive group behaviors

- *Cooperating*: Is interested in the views and perspectives of the other group members and is willing to adapt for the good of the group.
- *Clarifying*: Makes issues clear for the group by listening, summarizing and focusing discussions.
- *Inspiring*: Enlivens the group, encourages participation and progress.
- *Harmonizing*: Encourages group cohesion and collaboration. For example, uses humor as a relief after a particularly difficult discussion.
- *Risk Taking*: Is willing to risk possible personal loss or embarrassment for the group or project success.
- *Process Checking*: Questions the group on process issues such as agenda, time frames, discussion topics, decision methods, use of information, etc.

Destructive group behaviors

- *Dominating*: Takes much of meeting time expressing own views and opinions. Tries to take control by use of power, time, etc.
- *Rushing*: Encourages the group to move on before task is complete. Gets “tired” of listening to others and working as a group.
- *Withdrawing*: Removes self from discussions or decision making. Refuses to participate.
- *Discounting*: Disregards or minimizes group or individual ideas or suggestions. Severe discounting behavior includes insults, which are often in the form of jokes.
- *Digressing*: Rambles, tells stories, and takes group away from primary purpose.
- *Blocking*: Impedes group progress by obstructing all ideas and suggestions. “That will never work because...”

WebSupplement 4*: Day 3 – How will our team deal with conflict?

[*This supplement is written as instructions to the facilitator(s) running the teamwork exercises]

Goal

To promote awareness of the importance of conflict for team functioning, the diversity of ways members may respond to such conflict, and effective conflict management skills.

Rationale

All teams experience conflict. In fact, based on the sequential-stage theories, one of the stages of development that teams have to undergo in order to reach high levels of performance involves conflict: form, storm, norm, perform, adjourn (Tuckman 1966; Tuckman and Jensen 1977). Therefore, teamwork exercises are necessary that help build awareness of the importance of conflict for team functioning, the diversity of ways members may respond to such conflict, and effective problem solving and conflict management skills (below and WebPanel 2).

Context

KSC and PAS used this exercise on day 3 of the first 4-day face-to-face workshop of a newly formed interdisciplinary, single-nation, team that had a mix of team members, some who knew each other and some who did not. They found it helpful to read generally about modes of conflict before facilitating this exercise (eg chapter 8 in Johnson and Johnson [1991], chapter 3 in Smith and Imbrie [2007]). Facilitators may also find Callanan *et al.* (2006) and Morris *et al.* (1998) helpful when preparing for this activity. These two articles can help facilitators choose the best conflict instrument for their team. The former paper may also help facilitators frame the discussion before team members take the instrument (eg set up the context) and the latter may help the facilitators debrief the results, especially for international teams that may experience cultural differences in how they deal with conflict. See WebSupplement 1 for general suggestions for how to effectively use these (and other) teamwork exercises and WebSupplements 2–3 for previous days' teamwork exercises.

Exercise Resources

- A conflict mode instrument, such as Exercise 8.1 of Johnson and Johnson (1991), the Thomas Kilman Conflict Mode Instrument (<https://www.cpp.com/products/tki/index.aspx>), or the Kraybill Conflict Styles Inventory (www.riverhousepress.com/Conflict_Style_Inventory_Home_Page.htm).
- Flip chart with 5 dominant modes of dealing with conflict as column headers and markers.
- Two rooms – one set up with tables in a U-shape facing the front wall, and other with small tables for small group discussions. Alternatively, the room needs to have movable tables so that the room can be re-configured as needed.

Setting the Stage

Facilitator welcomes participants to the working meeting, presents the agenda for the day, and asks everyone to disable Wi-Fi and turn off their phones until the first break. On the basis of the discussions from the previous 2 days, the facilitator summarizes the diversity represented on the team, lessons learned about effective communication, and then introduces this exercise by talking about the importance of everyone being aware of the need for conflict to increase team functioning, the diversity of ways that members may respond to such conflict, and strategies for effective problem solving and conflict management.

Step-by-step instructions (approximate time, 1 hr; works on team functioning)**Part 1:** Why conflict? [~10 minutes for 15–20 participants – whole team]

1. The room should be set up in a U-shape, facing one wall that has a flip chart.

2. Facilitator shares with the group the developmental stages of team development (form, storm, norm, perform, adjourn; sensu Tuckman 1966; Tuckman and Jensen 1977), pointing out that even though most people would prefer to avoid conflict, it is actually needed in order for a team to establish team norms and perform (ie conflict is necessary for productive teams).

Part 2: How will I respond to conflict? [~30 minutes for 15–20 participants working independently]

1. Facilitator passes out the chosen conflict mode instrument, instructs each person to complete it while: (a) thinking about research situations and (b) answering openly and honestly without thinking too much about the answers. Upon completing these activities, each person is asked to use the flip chart to record a tally mark in the appropriate columns for their top 2 ways of dealing with conflict. This action indicates to the facilitator when members are done with the activity and the project team is ready to move on to the synthesis.

Part 3: Synthesis – How will our team respond to conflict? [~20 minutes for 15–20 participants – whole team]

1. Facilitator starts with a discussion about how everyone uses all 5 modes of dealing with conflict, that all 5 modes are necessary in different situations, but that everyone has mode(s) that they prefer to use. Summarize some of the characteristics of each mode, and point out that this exercise allows the team to build awareness about how others are likely to respond to conflict.

2. Facilitator adds up the tally marks for each column (mode of dealing with conflict) along the bottom of the flip chart table. Point out the diversity within the group, as well as commonalities, and talk about how the team can use the results to its advantage. Some discussion of case studies or scenarios can be useful at this point.

WebSupplement 5*: Day 4 – Project reality check – Who’s doing what and when during the next [week, month, semester, year]?

*[*This supplement is written as instructions to the facilitator(s) running the teamwork exercises]*

Goal

To promote individual and team time management and help the project establish (and meet) realistic timelines.

Rationale

This teamwork exercise addresses an issue that is near and dear to most scientists’ hearts and is a very important predictor of research outcomes: time management. In this case, we are concerned both with individual team member time management and that of the team as a whole. The exercise outlined below increases team communication and functioning by helping members appreciate and understand the diversity of roles, responsibilities, and time constraints that are represented on the team, which helps to set expectations about who will realistically be able to help with which team products and when. This exercise can be especially helpful in spurring honest conversations about which research outcomes to prioritize, who will lead such efforts, and what the timelines will be.

Context

KSC and PAS used this exercise on the last day of the first 4-day face-to-face workshop of a newly formed interdisciplinary team that had a mix of team members, some of whom knew each other and some who did not. See WebSupplement 1 for general suggestions for how to effectively use these (and other) teamwork exercises and WebSupplements 2–4 for previous days’ teamwork exercises.

Exercise Resources

- Meggin McIntosh’s “Available to Promise (ATP)” exercise: <http://justwhelmed.com/ATP.php>, www.GetaPlanGuides.com.
- Two rooms – one set up with tables in a U-shape facing the front wall, and another with small tables for small group discussions. Alternatively, the room needs to have movable tables so that the room can be reconfigured as needed.

Setting the Stage

Participants are welcomed to the workshop, presented with an agenda for the day, and asked to disable Wi-Fi and turn off their phones until the first break. Facilitators revisit the list of outcomes, contributions, and goals the research team has for the project (see WebSupplement 2), and caution that all likely cannot be done/achieved. They then introduce the exercise by talking about the importance of everyone knowing who can be called on, when, and for what, to ensure high team functioning and productivity.

Step-by-step instructions (approximate time, 1 hr; works on team functioning)**Part 1:** Identifying individual priorities and constraints [~10 minutes for 15–20 participants working independently]

1. The team should be in the room set up for small group discussions, or the room needs to be reconfigured for small group discussions.
2. Facilitator asks each person to think about and write down their different job responsibilities and the relative amount of time they spend on each for any given month, week, and day within a particular time period (Note that visual learners might be helped with this exercise by using Venn diagrams for each time period). Participants are asked to note discrepancies between responsibilities and time spent on each, especially across different time periods, and to think about the factors that might result in those discrepancies (eg A professor’s appointment might

be 40% teaching and 60% research, so for a month they might list these percentages; however, for any given day within that month, they may not allocate their time that way for a variety of reasons).

Part 2: Understanding others' lives [~20 minutes for 15–20 participants working in small groups]

1. Facilitator asks the participants to discuss their priorities and constraints in small, diverse groups of 3–4 participants. These groups are designated ahead-of-time to increase diversity of career stages and/or project roles during this portion of the meeting (eg one of each: professor, post-doc, graduate student, agency researcher). Composition can vary depending on the project and team, but ideas for promoting diversity in small groups include forming heterogeneous groups by discipline, career stage (but, students should not be outnumbered), or demographic characteristics (without outnumbering minorities [broadly defined]).

Part 3: Individual time management/ Available to Promise (ATP) [~20 minutes for 15–20 participants working independently]

1. Facilitators hand out a filled-in, example Available to Promise (ATP; pdf, <http://justwhelmed.com/ATP.php>, www.GetaPlanGuides.com) and a blank ATP for the timeframe that is most useful for the project period (eg 6 months). Ask each person to fill out the ATP, pointing out that the bottom row represents how much time they can commit to the large research collaboration during the coming period of time.

Part 4: Team time management, priorities and goals [~10–30 minutes, depending on whether #2 (below) is included, for 15–20 participants working as a whole team]

1. Facilitator leads a whole-group discussion about members' ATPs for the project. Topics brought up can range from logistical details such as who will be available to review a supplemental grant request during a particular month to more conceptual questions such as what are the implications of our collective ATPs for the list of project products, contributions, and goals.
2. This discussion may lead very nicely into revisiting the list of team products and revising the priorities and timeline in light of this project reality check.

WebSupplement 6: Creating effective team policies

WebSupplements 2–5, and other teamwork exercises (eg WebPanel 2), can feed into the establishment of team standards of behavior (ie team norms). Explicit team norms create clear expectations among team members, which can increase levels of trust and maximize benefits for all team members (Goring *et al.* 2014), thus increasing research team functioning and productivity (eg Smith and Imbrie 2007). These norms can then result in team policies about important team practices such as data sharing and co-authorship. One example of the positive effect of adopting such explicit policies comes from SJG: “In drafting an upcoming paper, we were faced with the challenge of naming authors. Because this project is the result of a large collaboration, a number of individuals have contributed to the paper in many different ways (eg participating in workshop discussions, providing data, commenting on manuscript drafts). To achieve our goals of author inclusion and honesty about the role that individuals played in crafting the paper, I distributed a list of roles to potential co-authors. I indicated that co-authorship would be granted if they had contributed to three or more of the eight possible roles, and gave potential co-authors the opportunity to describe their roles. This approach allowed individuals to opt in or opt out in a straightforward manner and helped me, as an early-career researcher, by providing a clear argument as to why someone should or should not be included on the paper in case of conflict, even if they were more senior than me.” We have found that these policies are iterative, and that sometimes surprising conversations occur during policy development, especially among researchers from different disciplines. These policies should be viewed as living documents that change over time to reflect changing team membership and project goals. Another source for existing policies is the “Operating Principles and Procedures” document developed for the Global Lakes Ecological Observation Network (GLEON) that can be found at: www.gleonrcn.org/media/GLEON_OpPrincProc.pdf.

Below, we provide an example of four policies that KSC and PAS have created and used for one of their teams:

- A. Authorship/co-authorship
- B. Project personnel activities, responsibilities, and expectations
- C. Data sharing and access to project database(s)
- D. Collaborations with non-project researchers

A. Authorship/co-authorship Policy: This policy document was first drafted by participants of the CSI-Limnology Project (www.csilimnology.org; NSF-MacroSystems Biology awards 1065786, 1065818, 1065649) during 2011 and has been subsequently revised to reflect the needs and perspectives of the team. The document is written as a memo that would be sent to all project participants during the early phase of research toward a specific manuscript by the lead author of the manuscript. This policy should be viewed as a living document that changes over time to reflect changing team membership and project goals. Following the memo, we provide some additional background information and resources that may be helpful for your team.

Preamble

This document is meant to provide guiding principles for research projects that are likely to lead to a research manuscript. Manuscripts that are position-pieces or commentaries may need different criteria; however, this policy document can be used to start the conversation about authorship for those types of projects as well. This document is written as a memo from a lead author of a project-manuscript that is sent to ALL team members during the early phase of the research project. Early notification of a research project ensures that everyone knows what research is being conducted by whom and that all interested parties are identified early in the research process. Once co-authors are identified, and research continues, the memo is re-sent to only those participants who have signed on as co-authors to help ensure a conversation about author responsibilities and potential author-order of the manuscript. This document has been especially helpful for the CSI-Limnology Project because our project includes project personnel from multiple institution types, universities, disciplines, and career stages.

MEMO

TO: Potential co-authors

FROM: Lead author

RE: Authorship of manuscript (hereafter abbreviated as MS) titled:

We are contacting you because you have been listed as a potential co-author on the above manuscript that is associated with the CSI-Limnology project. On the next page is a list of responsibilities for co-authors on manuscripts. This table is intended to foster an open dialog on authorship that starts at the very beginning phase of a manuscript and carries through until manuscript submission and acceptance. This document is intended to clearly define each co-author's responsibilities and accomplishments throughout the effort, as well as the overall strategy for determining co-authorship as described below.

1. **It is recommended that co-authors participate in at least a single activity in 2 of the 3 major categories in the table below AND participate in a total of 3 activities.** Note that some contributions that are often relegated to the acknowledgments section are included in the table, but that those participants who contribute in only one or two of these activities would be placed in the acknowledgments.
 - a. **Exception to this guideline:** We recognize that all manuscripts may not neatly fit within this guideline. For example, for interdisciplinary projects in which non-limnologists/ecologists take the lead on manuscripts, this guideline may need to be relaxed to accommodate the domain experts (limnologists/ecologists) who should be listed as co-authors even if they do not meet the above minimum requirements, but were essential for manuscript success (eg helped with project conception and model interpretation). Alternatively, for limnological manuscripts in which non-limnologists provide critical methods and analytical techniques to the analysis, some of these criteria may also be relaxed. We expect that there may be additional exceptions to this general guideline and that details will be discussed for each manuscript as they arise.
2. **In general, data providers are not assumed to be co-authors.** Providing data is not considered a contribution large enough to constitute co-authorship. However, in the data-sharing process, if any data-provider has expressed an interest in collaborating on specific projects, it is our responsibility to contact that person and explore collaboration and co-authorship. Such a person would be included as a co-author if they agree to participate following the guidelines outlined here. Note that if a CSI participant proposes a manuscript that contains only a handful of data sources, then it is his/her responsibility to contact the data providers prior to doing so to ask permission.
3. **Citations of original data sources (including names and agencies) will be provided on the CSI-Limnology website and in a published technical report.** We will not be able to cite data sources in each manuscript's acknowledgements because the full list of sources would be too long for journal guidelines.
4. **All co-authors must approve the final version of the manuscript prior to submission.** In fact, it would be unethical to submit a manuscript in which all co-authors did not read and approve the final submitted version. This task is not included in the contributions table because all co-authors must do it.
5. **Co-authors are held accountable for the content of the manuscript.** This idea provides an important distinction between a co-author and someone who is acknowledged. See below for further rationale and additional information. We recognize that every co-author will not have a full working knowledge of all aspects of the research; however, they need to know enough to defend the work.
6. **It is recommended that an author-contribution paragraph be written for each manuscript.** This step is important to ensure that all co-authors (particularly early-career ones) get recognition for the contributions that they make to this project's highly collaborative efforts. If journals do not publish the paragraph, we will try to make the paragraph available on our website.

The table on the next page describes the specific contributions that co-authors can make and that we would like each potential co-author to fill out. Toward the end of the manuscript analysis and writing phase, the lead author(s) will revisit this table and ask you to finalize the contributions that you have made to this specific manuscript. This table will be used to draft the author contribution paragraph described above and that will be published with each article (or, placed on our project website).

Author contributions by: *Insert your name here and fill in table below*

Activity	Your specific contribution
CATEGORY 1: Concept and Design	
<u>Conceived of the manuscript idea/concept</u> – <i>help to frame the overall idea for the manuscript, research questions, or scope; individually or collectively with co-authors</i>	
<u>Designed/outlined the manuscript</u> – <i>help to determine structure and content of the manuscript individually or collectively with co-authors</i>	
<u>Supervised co-authors and manuscript progress</u> – <i>oversee the progress on the manuscript</i>	
CATEGORY 2: Research	
<u>Collected data (fieldwork), or compiled or synthesized data for the manuscript</u>	
<u>Performed data analysis or modeling</u>	
<u>Contributed new methods or models</u> – <i>but did not actually run the models</i>	
<u>Interpreted results</u> – <i>help to interpret meaning of results individually or collectively with co-authors</i>	
<u>Drafted figures and tables</u>	
CATEGORY 3: Writing	
<u>Wrote sections of text</u> – <i>even if eventually these sections were not included in final version</i>	
<u>Performed critical reviews</u> – <i>reworking the manuscript for intellectual context at all draft stages (ie not just spelling and grammar edits)</i>	
CATEGORY 4: Other	
<i>Contributions not listed above, please specify</i>	

Background information and resources for authorship policies

On the distinction between being listed in the acknowledgments versus being a co-author from Weltzin *et al.* (2006):
“Drawing the line between acknowledgements and co-authorship can be challenging and one way of thinking about the differences may be to ***consider whether or not the participant is responsible and accountable for the article***. A contributor receiving credit for the article should be willing to be held accountable for its contents and not be just responsible for a portion of work involved. In contrast, an acknowledgement may contribute formal or informal ideas to ongoing projects, collect enormous amounts of data, and develop and/or conduct statistical analyses, but may not be accountable for the final contents of all or even portions of the final manuscript.”

Example author-contributions paragraph from Weltzin *et al.* (2006)

Panel 1. Author contributions for Weltzin *et al.* 2006

JFW co-conceived and co-developed the idea for the manuscript, co-refined the intellectual content and scope, edited all drafts, prepared the final version of the manuscript, and facilitated the gathering of contributors. RTB co-conceived and co-developed the idea, edited all drafts, and assessed historic trends in authorship in Ecology. LTW initiated the project, co-developed and co-refined the intellectual content, and wrote the first two drafts. JKK co-developed the idea, edited all drafts, and conducted the keyword search. ECE co-developed the idea and coordinated the authorship survey. JFW is the guarantor for the integrity of the article as a whole.

Example acknowledgement section from Weltzin *et al.* (2006)

Acknowledgements from Weltzin *et al.* 2006

P Allen contributed to initial discussions of this topic and co-refined the intellectual content of earlier versions of the manuscript. C DeVan assisted with data collection and organization for Figure 1. The survey on authorship was developed and implemented with the help of M Fitzpatrick, C Iversen, J Nagel, and L Souza. Comments from P Cole, S Collins, O Dermody, M Fitzpatrick, C Iversen, C Reilly, N Sanders, and L Souza improved earlier versions of the manuscript.

Additional information

Guidelines for authorship have been discussed in a recent paper (Duke and Porter 2013) as well as been published by the Ecological Society of America (2006) and the Proceedings of the National Academy of Sciences (2006):

Duke CS and Porter JH. 2013. The ethics of data sharing and reuse in biology. *BioScience* **63**: 483–89.

ESA. 2006. Ecological Society of America. Code of Ethics. Adopted August 2000.
www.esapubs.org/esapubs/ethics.htm.

PNAS. 2006. Proceedings of the National Academy of Sciences of the United States of America. Information for authors. www.pnas.org/site/authors/journal.xhtml.

B. Project Personnel Activities, Responsibilities, and Expectations: This policy document was first drafted by participants of the CSI-Limnology Project (www.csilimnology.org; NSF MacroSystems Biology awards 1065786, 1065818, 1065649) during 2012 and has been subsequently revised to reflect the needs and perspectives of the team. This document has been especially helpful for increasing interdisciplinary understanding and setting expectations across disciplines and career stages, but has also well served our team to facilitate important conversations about philosophical differences regarding the roles of various project personnel within disciplines, both within and across institutions. This policy should be viewed as a living document that changes over time to reflect changing team membership and project goals.

Preamble

This document is intended to help foster interdisciplinary collaborations and to more effectively set expectations across disciplines and career stages. However, it has also well-served our team to facilitate important conversations about philosophical differences regarding the roles of scientists at all career levels within disciplines both within and across institutions. Another important impetus for this document is to ensure that there is equity in project work across graduate students and post-docs on the CSI-Limnology project across institutions and disciplines.

This is an ambitious project that requires a wide range of disciplinary and technical expertise and very efficient collaboration among team members. Our team includes approximately 15–20 researchers with aquatic ecology, biogeochemistry, landscape ecology, and macrosystems ecology expertise, as well as technical expertise in GIS, spatial modeling, Bayesian hierarchical modeling, data mining, and database management. Due to the size and nature of the project, it has critical needs in the area of project management, student and post-doc mentoring, and facilitation of effective collaborative research interactions. We use and expand on project management strategies that we have employed in past projects as a guide for this project, with a focus on transparent and fair interactions across team members, frequent communication, clear goals and objectives for each participant, and active engagement of all personnel.

We have a very inclusive policy for project participants. We define project participants as any individual (PI, senior personnel, staff or student) who was part of the 2011–2016 grant, in addition to those individuals who have joined the project part-way through the grant timeline and are funded by the grant. We expect all project participants to be full collaborators and contributors on the project. In addition, we feel that early-career scientists (ie post-docs and graduate students) should be involved in all aspects of the research project that co-PIs and senior personnel are involved in, including collaborations and interactions with project participants outside of their home institution as much as possible. We also hope to provide leadership opportunities for early-career scientists for various aspects of the project. Because we recognize the challenges of conducting interdisciplinary research, we try to make clear our expectations for all project personnel while retaining flexibility to accommodate different levels of involvement both within and across disciplines. Below we describe expectations for all project participants.

General expectations of all project participants

Project communication and file sharing

- Communicate in a respectful and inclusive fashion
- Participate in monthly teleconference calls
- Attend the annual week-long all-hands project workshop
- Participate in teleconference calls for sub-team project efforts or manuscripts
- Join Dropbox for project file sharing, add/remove files as needed, and name files clearly
- Present ‘product or analysis’ plans to the team early in the planning phase via monthly teleconference call to ensure complete communication
- Solicit ‘product or analysis’ collaborators/co-authors by distributing the CSI-Limnology co-authorship memo to the group early in the planning phase
- Post any presentation related to the CSI-Limnology project (and the associated abstract) on Dropbox in the ‘manuscripts-presentation’ sub-folder for the year of the presentation.

- Place the citation for all activities related to CSI-Limnology that should be recorded for the annual report to NSF in the annual report log on Dropbox.

Research activities – database development and maintenance

Due to the complex nature of building the large integrated geospatial database for this project, it is expected that all participants contribute to some aspect of the creation, QA/QC, or documentation of the database by contributing to some of the activities listed below. In general, we expect limnologists and non-limnologists to be involved in activities that are related to their area(s) of expertise.

Examples of work that all project participants are expected to contribute to, according to their area(s) of expertise:

- Database design
- Gather datasets and methods from individual researchers, agencies, etc.
- Create/author metadata for each dataset entered into the database
- Gather GIS datasets and research methods related to these data
- Help in the development of methods for GIS analysis such as watershed delineation
- Database activities such as database management, backup, access, querying, user interfaces, etc.
- Help view/analyze early database versions to identify errors in database
- Conduct analyses/make recommendations for database issues such as detection limits, comparability of lab methods, lake size thresholds, etc.
- Quality Control/Quality Assurance of the limnology database
- Quality Control/Quality Assurance of the GIS database
- Create/author documentation of the limnology database
- Create/author documentation of the GIS database
- Conduct agency/outreach activities
- Develop and maintain webpage
- Database maintenance

Research activities – analysis and manuscripts

All project participants are expected to serve as coauthors on one or more project manuscripts. We also suggest that each project participant serve as a lead author on a minimum of one manuscript or critical analysis that facilitates the database development or use (described above). For all CSI-Limnology manuscripts, the lead-author will write an authorship contribution paragraph. If the journal does not publish the paragraph, it will be posted on csilimnology.org. In addition to these general expectations, we also expect the following.

- *Limnologists*: write and share R code (or other techniques) for processing data and analysis
- *Non-limnologists*: apply analytical methods to the database for particular research questions; develop new analytical methods (as needed)

Research activities – requirements for responsible conduct of research

Graduate students, post-docs and staff who are funded and supervised on NSF projects are required to show that they have participated in professional development activities related to the above. Each institution is required to fulfill this requirement.

Additional expectations of lead PI

- Serve as supervisor of database manager
- Serve as supervisor of GIS analyst
- Serve as supervisor to own graduate students or post-docs
- Coordinate activities above across all project participants
- Facilitate communication such as monthly teleconferences and annual project meetings
- Provide overall project management and database stewardship
- Facilitate the participation of co-PIs in collaborative decision-making on the project
- Serve as lead author on one or more manuscript during the duration of the project

Additional expectations of co-PIs

- Serve as supervisor to own grad students or post-docs
- Help coordinate and lead specific sub-teams of the research project
- Participate and help to make decisions regarding overall direction of project
- Serve as lead author on one or more manuscript during the duration of the project

Additional expectations of Senior Personnel

- Serve as a lead on either a manuscript or a critical analysis that facilitates the database development or use (see above)

Additional expectations regarding early-career scientistsResearch topics

It is assumed that each early-career scientist will choose his or her research topics primarily with their major advisor/supervisor. However, all scientists are expected to communicate their proposed research to the entire CSI-Limnology team to solicit feedback and be sure that there is not undue overlap with any student dissertations or ongoing research efforts.

For graduate students who are funded on the project, and are limnologists: we expect that at least some of the ‘chapters’ of their dissertation will relate directly to the CSI-Limnology project. We recognize that some of these students may have a dissertation chapter that is only loosely related to the project given their research interests (eg students who may wish to have a field-component as part of their dissertation). For graduate students who are funded on the project, and are not limnologists (ie computer scientists), there are two possible models for inclusion in the CSI-Limnology project, both of which are valid and are to be decided based on communication among the graduate student, advisor/supervisor and lead PI: (1) the student can be hired to work ~15 hrs a week on the project to conduct analysis needed to answer research questions, but not take the lead in writing the manuscript. Rather, they would collaborate with other researchers who would take the lead on the manuscript, or (2) the student can conduct his/her dissertation on a topic related to the field of computer science, but also demonstrate in at least one chapter (or manuscript), the application of the proposed solution to a problem related to the CSI-Limnology project. With this latter model, there likely will be other opportunities for the student to contribute to additional research projects for which their proposed computational solution may be applicable, but he/she would not take the lead on these additional resulting manuscript(s). For both models, the computer science student is expected to contribute to database maintenance, access, security, etc. as described in the proposal, for the amounts of time required for all graduate students funded on the project (see below). Once all graduate students who are funded on the project have decided on research questions and written a proposal, it is expected that the student present his/her proposed research to the entire CSI-Limnology team to ensure complete communication of research plans among all project personnel. It is also expected that the student posts either the proposal or a shortened version of the proposal in Dropbox for future reference by project participants.

Each early-career scientist and his/her advisor/supervisor should discuss the degree to which other project participants should serve as co-authors or direct collaborators on particular products, and then solicit feedback from the group. The general policy of co-authorship (and thus direct collaborations) for the CSI-Limnology project (see the co-authorship policy document) applies to student dissertations/manuscripts and post-doctoral manuscripts of CSI-Limnology participants. However, it is assumed that the early-career scientist will be the lead author and likely the primary data analyst on these collaborative manuscripts. If an early-career scientist leaves his/her institution prior to publishing these manuscripts, he/she will have ~1 year to submit their work before a co-author (likely the advisor/supervisor) has the option to take over writing and submitting the manuscript. Exceptions can be made after discussion among all parties involved.

Contributions and work on CSI-Limnology-related tasks (*ie Non-dissertation activities*)

It is expected that all project participants will help with the day-to-day work that needs to be conducted to collect, develop, build, maintain, and access the large database that forms the basis of this project. Philosophically, we feel that this is important not only because we need the work done, but because it will also help early-career scientists get a better feel for the database, project activities, and to learn the challenges of conducting research at this scale. For early-career scientists funded on the project, it is assumed that a portion of his/her time will be devoted to help with the database development and documentation, even if it does not directly pertain to his/her dissertation. In many projects such as this, it is not always easy to anticipate and stipulate the exact number of hours needed for such work. However, in an effort to be equitable across students (within and across institutions), we have some suggested guidelines for hours that we expect students to provide to the project. Typically, we will assign tasks to students from which they may derive some value and that do not take an undue amount of time in any one semester.

Graduate students: To ensure that any one graduate student does not shoulder more of the burden than others, we recommend that each graduate student does ~15 hrs/week of such work for at least 2 of the semesters for which they are funded on the project. During some of the summers in which students are funded, they may also be asked to work ~20 hrs/week on such work, depending on project needs and timelines. The details of the work will be decided through open communication among each graduate student, the adviser/supervisor and the lead PI.

Post-docs: We expect post-docs who are funded on the project to contribute to project research tasks in support of the overall project in proportion to the amount of funding they receive from the CSI-Limnology project. Thus, if they are paid half-time on the project, their obligations to the project are 50% lower than a post-doc that is paid full time. The actual work/tasks to be done will depend on the expertise of the post-doc, the project needs and the timing of activities the post-doc is involved in. The details will be decided through open communication among the post-doc, the supervisor and the lead PI.

Exceptions: We expect the above statements to be general guidelines for work and project development. For example, we recognize that it is acceptable for many graduate students in computer science to do at least one summer internship to gain valuable work experience. During such summers, the students are not funded on CSI-Limnology project and would not have the expectation to make progress on their research or contribute to the project work. However, the student must inform his/her advisor about such intention as early as possible so that the information can be shared with other project participants. In addition, we recognize that some early-career scientists may be involved in the CSI-Limnology project who are not funded by the project grant. Because we expect these students to be in the minority, we expect the student's advisor/supervisor will communicate with the lead PI to discuss the involvement of the student on the project and to clearly lay out expectations and responsibilities, which will then be shared and discussed with the project co-PIs. However, depending on the level of involvement of the student on the project and the degree to which they use the CSI-Limnology data, it is expected that they will contribute hours to the project as needed, but to a lesser degree than students fully funded on the project. Similarly, for students who are partially-funded on CSI-Limnology, their obligations regarding hours can be scaled accordingly.

C. Data Sharing and Access to Project Database(s) Policy During the Project Period (2011-2016): This policy document was first drafted by participants of the CSI-Limnology Project (www.csilimnology.org; NSF-MacroSystems Biology awards 1065786, 1065818, 1065649) during 2011 and has been subsequently revised to reflect the needs and perspectives of the team. This document has been especially helpful for CSI-Limnology because our project (a) includes project personnel from multiple institution types and universities, (b) compiled data across large temporal and spatial extents that were sampled by different agencies, universities, and individuals, and (c) is required by NSF to make the data publically available at the end of the project period. This policy should be viewed as a living document that changes over time to reflect changing team membership and project goals.

Policy: The LAGOS database will be hosted on a secure server at MSU, backed up daily, and managed by the database administrator, Ed Bissell. Data exports will be provided to the CSI Limnology team members on the shared Dropbox folder for the duration of the project (2011–2016) along with documentation for each export version of the database. The database administrator is the only person with authority to modify the database and will do so only as needed, with associated documentation describing the modifications. Project personnel and collaborators are not be allowed to share or make available in any form any data contained within the database during the duration of the project, unless discussed with the lead PI (other than through publication of research results). In special cases, small portions of the database may be shared with data providers, or other researchers whose research does not overlap with CSI Limnology team members, but only after requested and discussed with all project PIs and other project participants.

D. Collaborations with Non-project Researchers Policy: This policy document was first drafted by participants of the CSI-Limnology Project (www.csilimnology.org; NSF-MacroSystems Biology awards 1065786, 1065818, 1065649) during 2012 and has been subsequently revised to reflect the needs and perspectives of the team. This document has been especially helpful for CSI-Limnology because our project includes many project personnel from multiple institution types and universities, resulting in a large professional network. Our use of the policy has been mainly internally in order to facilitate conversations to increase our understanding of each other's expectations regarding collaboration. This policy should be viewed as a living document that changes over time to reflect changing team membership and project goals.

Preamble

This document is intended to clarify the participation of new research and staff scientists in the CSI-Limnology project, beyond the participants in the original CSI-Limnology project grant (as PI, senior personnel, post-doc, or graduate student). Because this project includes many personnel from multiple institution types and universities, resulting in a large professional network, we have frequent collaboration requests. On the one-hand, we recognize that creating and maintaining a high-performing research team requires many resources, and the addition of new members can result in temporary decreased productivity while the new team is getting used to how to most effectively communicate and interact. On the other hand, we value diversity and recognize the need for new team members in order to increase cross-fertilization and to provide new intellectual stimuli. Therefore, this policy exists in order to help facilitate the conversation about potential **new** CSI-Limnology collaborators. Note that this policy does not apply to new graduate students or post-doctoral researchers of CSI-Limnology PIs and senior personnel.

Policy: If a request for collaboration (on a manuscript or research effort) comes to any of the individual CSI-Limnology team members, then all PIs must be contacted for discussion regarding the potential collaboration and how it might fit into the overall project goals. If the PIs feel the collaboration is appropriate, then the potential collaboration is discussed among all project personnel so that everyone has the chance to provide input regarding the collaboration. For example, we will pay close attention to issues such as whether the requester brings a different perspective to the team that might be valuable for the project and whether the requester's interests overlap with in-progress or planned research.

When outside collaborators are invited to participate on CSI-Limnology manuscripts or research efforts, all policy documents will be shared with the potential collaborator, with a special focus on our authorship policy that states that all CSI-Limnology project participants have the option to participate in any manuscript they are interested in, including those led by outside collaborators.

WebSupplement 7*: Assessing team functioning

[*This supplement is written as instructions to the facilitator(s) running the teamwork exercises]

Goal

To promote individual and team reflection, provide an opportunity for all team members to give feedback, and to improve team functioning, all with the purpose of achieving and maintaining “high-performing collaborative research team” status.

Rationale

A characteristic of high-performing collaborative research teams is their frequent assessment of team functioning (Smith and Imbrie 2007). We developed the survey below based on our experiences with teams, the research that went into writing this paper, and a survey developed for teams used in education (CATME; www.catme.org; Ohland *et al.* 2012; see citations in survey categories C–I).

Context

KSC and PAS used this exercise on day 1 of the second 4-day face-to-face workshop of an interdisciplinary team (ie a year after using exercises such as those found in WebSupplements 2–5 at our first workshop). See WebSupplement 1 for general suggestions for how to effectively use these (and other) teamwork exercises.

Exercise Resources

- This article (Cheruvilil *et al.* 2014)
- Anonymous formal assessment administered online (eg survey below administered on Survey Monkey; www.surveymonkey.com)
- Handouts of the summarized survey results (1 per team member)
- Two rooms – one set up with tables in a U-shape facing the front wall, and the other with small tables for small group discussions. Alternatively, the room could have movable tables so that it can be reconfigured as needed.

Setting the Stage

Facilitator welcomes participants to the workshop, presents the agenda for the day, and asks everyone to disable Wi-Fi and turn off their phones until the first break. The facilitator introduces the exercise by talking about the importance of assessing team functioning to maximize team functioning and productivity and places the exercise into the context of the discussions the team has had over the past year and the results of the formal assessment. Note that the survey below relies solely on self-reported responses, and thus self-perceptions. Therefore, the results should be discussed as such.

Step-by-step instructions: (approximate time, 1 hr; works on team functioning)

Before the workshop, all team members should read this paper (Cheruvilil *et al.* 2014) and complete the formal assessment anonymously. The facilitator should compile and summarize the survey results prior to the workshop. Then, during the workshop, the facilitator presents summaries of the survey results and facilitates a discussion of the entire team to build a plan for a better future that increases team functioning and meets both individual team member’s needs and the entire team’s goals.

Part 1: Assessing team functioning [facilitator only]

1. Facilitator prepares the survey

Part 2: How can we become/stay a high-performing collaborative research team (ie Why formal assessment?)? [1–2 hours for each individual team member, prior to workshop]

1. Ask all team members to read this article (Cheruvilil *et al.* 2014), and reflect on how the team has performed since the last workshop.
2. All team members complete the survey prior to the start of the team workshop.

Part 3: Summary of the formal assessment – What was surprising? [~10 min – whole team]

1. Facilitator provides a summary of the results of the survey.
2. Ask team members for their immediate reaction to results.
3. Pass out handouts of the summarized survey results.

Part 4: What was most interesting? What can our team work on in the future? [~20 min for 15–20 participants – small, diverse groups]

1. Break the team up into small, diverse groups (eg gender, career stage, discipline).
2. Ask the small groups to come up with two lists based on the survey results:
 - a. Interesting survey results.
 - b. What the team should improve upon in the coming year.

Part 5: Synthesis – What will our team improve upon in the coming year? [~20 minutes for 15–20 participants – whole team]

1. Facilitator debriefs the exercise by recording all of the small group responses and making a short list of the major factors that the team would like to improve upon for the coming year.

Survey Instructions: We are asking for you to complete this survey in hopes of ensuring that our research team is or becomes a high-performing collaborative team. Please be sure to read Cheruvilil *et al.* (2014) before completing the survey, complete the evaluation in private, do not discuss your answers with anyone else, and answer each question as accurately as possible. Except for answers to the last two questions, the team assessment leaders will not look at individual answers (we will only examine summary statistics). In addition, we ask for no names on this survey so that we can best ensure confidentiality. Note: Throughout the survey below, X would be replaced by the name of the research team being assessed.

A. Team performance (entire team)

1. Characterize the performance level of X research team based on the following definitions.
 - a. Pseudo-team: A team composed of members with little training or interest in working in a team, who perceive competition within the team, and who see little need for actually working as a team. These teams hinder performance and achieve only to the level of the lowest-performing member.
 - b. Imbalanced team: A team in which performance level is not hindered, but does not exceed that of the highest-performing team member.
 - c. High-performing collaborative team: A team committed to a common purpose, performance goals, and approaches, in which members hold themselves, individually and mutually, accountable. These teams are able to successfully work on very complex problems and achieve high levels of productivity.

d. Highest-performing collaborative team: A team that outperforms any reasonable expectations in meeting team goals solely because of an exceptionally high commitment of all members to each other and the team's success. This is the rarest type of research team.

2. Rate X on the following qualities of a high-performing collaborative team (1-Low to 5-High)

- a. Diverse career stages of members
- b. Diverse degree of team member incumbency or familiarity
- c. Diverse interaction modes (disciplinary generalist, disciplinary specialist, interdisciplinary broker, and outwardly engaged member) of team members
- d. Diverse disciplinary backgrounds of team members (please consider both the total number of different disciplines and the equitability in team members per discipline)
- e. Diverse points of view
- f. Social sensitivities of entire team
- g. Emotional engagement of entire team

B. Team member composition (individual members)

3. What is your career stage?* Please choose the most applicable category from the following list:

Undergraduate student, graduate student, postdoctoral associate, professional research support staff (including academic, government, and private/industrial employees), pre-tenure faculty, tenured mid-career faculty, tenured senior faculty

4. What is your primary discipline?*

5. Which of the following best describes your interaction mode (note that you may consider yourself a combination of two or more of these modes, but choose the one that you think contributes most to the team)?

- a. Disciplinary generalist: You do not specialize in any one discipline, but are able to integrate ideas from a wide range of research knowledge.
- b. Disciplinary specialist: You specialize in a particular discipline and are the leading authority of that discipline in your team.
- c. Interdisciplinary broker: You serve as a conduit and catalyst for transferring knowledge among disciplines.
- d. Outwardly engaged member: You facilitate cross-fertilization of ideas and opportunities for new team membership by connecting your research team to others.

6. Rate your interpersonal skills (1-low to 5-high)

- a. Social sensitivity: The capacity to successfully navigate a full range of social relationships and interactions. This has also been referred to as emotional intelligence, social intelligence, or people skills.
- b. Emotional engagement: The presence and depth of feelings, both personal and professional, to other team members and the project as a whole.

C. Team conflict (keep in mind that conflict is not necessarily bad) adapted from Jehn and Mannix (2001)

Rate X on the following questions (1-None or not at all to 5-Very much or very often):

- 7. How much team conflict is there about task responsibilities?
- 8. How much conflict of ideas is there among teammates?

D. Team satisfaction adapted from Van der Vegt *et al.* (2001)

Rate your level of satisfaction with X (1-Strongly disagree to 5-Strongly agree):

- 9. I am satisfied with my present teammates.
- 10. I am very satisfied with working in this team.

E. Team interdependence adapted from Van der Vegt *et al.* (2001)

- 11. In order to complete the research goals for X, the individual team members needs to collaborate extensively. (1-Strongly disagree to 5-Strongly agree)

F. Team perspectives adapted from Carless and de Paola (2000) and Loughry and Tosi (2008)

Rate X on the following characteristics (1-Strongly disagree to 5-Strongly agree):

- 12. I'm unhappy with my team's level of commitment to the team's goals.
- 13. Our team members have conflicting definitions of research success.

G. Peer Influences adapted from Loughry and Tosi (2008)

How often do members of X... (1-Almost never to 5-Almost always)

- 14. Urge other team members to do the best possible job?
- 15. Tell team members that they did a good job?
- 16. Communicate openly within the team about members' performance?
- 17. Let the project leaders know if a team member is not meeting expectations?

H. Team Transition Processes adapted from Marks *et al.* (2001)

To what extent does X actively work to... (1-Not at all to 5-To a very great extent):

- 18. Identify our main tasks?
- 19. Identify the key challenges that we expect to face?
- 20. Determine the resources that we need to be successful?
- 21. Develop a shared understanding of our purpose or mission?
- 22. Set goals for the team?
- 23. Prioritize our goals?
- 24. Set specific timelines for each of our goals?

I. Team Action Processes adapted from Marks *et al.* (2001)

To what extent does X actively work to... (1-Not at all to 5-To a very great extent):

- 25. Regularly monitor how well we are meeting our team goals?
- 26. Develop standards for acceptable team member performance?
- 27. Balance the workload among our team members?
- 28. Assist each other when help is needed?
- 29. Communicate well with each other?
- 30. Re-establish coordination when things go wrong?
- 31. Have work products ready when others need them?

J. Optional, Open-ended Questions

32. Do you have any confidential comments regarding team performance, composition, or structure that you would like to share? These comments will only be shared directly with the team assessment leaders.

*Note that whether you ask these two questions will depend on the composition of your team. For the survey to be truly anonymous, you may need to remove questions that make team members easily identifiable to the facilitator (eg if your team only has one computer scientist, then you would not want to ask a question requiring them to identify their discipline).