The Ocean Health Index Assessment Manual

Contents

1 Introduction

1.1 The Ocean Health Index

The Ocean Health Index (OHI) project was created with a strong foundation in communication and collaboration. Following the initial publication by Halpern *et al.* 2012 in *Nature*, we have conducted global assessments annually (in 2013, 2014, and ongoing), and have conducted smaller-scale assessments for the U.S. West Coast (Halpern *et al.* 2014), Fiji (Selig *et al.* in press), and Brazil (Elfes *et al.* 2014).

We have also developed the **OHI Toolbox** and **WebApps** to enable any group to conduct independent assessments using the OHI framework and modifying it to their needs. The Toolbox enables the OHI framework to be customized to any area of interest, incorporating whatever goals, data, indicators, and priorities regarding ocean-derived benefits that are relevant and available to the chosen spatial scale. Information is presented through the WebApps, which are used for orientation, visualization, and reporting.

This manual provides information for:

1. Planning an assessment
2. Navigating the OHI WebApp to visualize data at global and regional scales
3. Modifying data and models within the Toolbox for an independent assessment
4. Guidance for frequently asked questions and troubleshooting

2 Introduction to OHI Assessments

> **Section Summary:**
>
> This section provides an overview of conducting an OHI assessment. In each assessment, goals are scored from 0 to 100 and then aggregated to produce an overall Index score. An assessment requires data, indicators, and priorities that are appropriate for each context.
>
> TIP: The process of conducting an OHI assessment is as valuable as the results for policy and management decisions.

Assessments using the OHI framework can be most relevant to policy and management decisions when they are conducted at smaller spatial scales (e.g., countries, states, provinces, ecoregions, bays, etc.). Using ten criteria (called goals), the Index scores on a scale of 0 to 100 how well coastal regions optimize their potential ocean benefits and services in a sustainable way relative to self-established reference points (targets). Relevant goal models are developed based on the best available information, which can be either raw data or composite data, or previously developed indicators.

The process of conducting an OHI assessment is as valuable as the final results. This is because while conducting an OHI assessment you will identify gaps in knowledge and data, produce decision-relevant information, and create an ocean alliance that combines knowledge and cultural values across disciplines. Conducting an OHI assessment requires engagement from as many different groups as possible, including research institutions, government agencies, policy groups, non-governmental organizations, and the civil and private sectors.

Assessments can incorporate higher-resolution data and indicators, local priorities and preferences, and develop tailored goal models and reference points, which produce scores that better reflect local realities. If a goal is not relevant in the local context, it can be excluded entirely. When you change goal models, though, it is important to capture the process in order to justify decisions that will inform the results. Similarly, pressures and resilience measures can be refined using local data and indicators. Index scores are only as good as the data on which they are based. **Finding the best data and indicators available is crucial for obtaining meaningful findings that can help inform decision-making.**

OHI assessments most often involve several **regions** within an overall **study area**. For example, in the global assessment, there were 221 regions (nations and territories) within the study area (global coastal oceans).

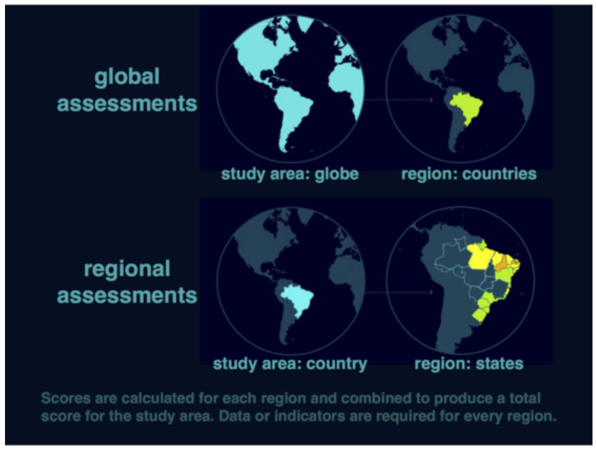


Figure 1: Figure. Global vs. regional assessments. Scores are calculated for each region and combined to produce a total score for the study area, whether at the regional, country, or global level.

Goal scores are calculated for each region separately and then combined to produce an overall Index score for the region. Index scores are combined using an area-weighted average to produce the Index score for the overall study area.

Scores can then be visualized to communicate the results to stakeholders. For example, the **flower plot** shown in the figure demonstrates a useful way to represent OHI scores. Goal or sub-goal scores are shown around the outside of the plot. The length of each 'petal' represents the goal score, while the width of each petal represents the relative weighting of the goal or sub-goal. Sub-goals are weighted equally by default, as shown here, but can change depending on the regional context.

Clear communication and transparency of the process are fundamental to the Ocean Health Index overall.

3 Overview of the OHI Toolbox

Section Summary:

In this section, you will learn how to access and use the OHI WebApps. Once using the WebApp, you can conduct a preliminary assessment and use the built-in functions to compare input layers, output scores, and change data display options.

3.1 Background

OHI WebApps are websites created to facilitate independent assessments, and one is available for nearly every coastal nation or territory. The WebApps are meant to be a 'Starter Kit' and are available through http://ohi-science.org using a three-letter identifier in the URL. For example, Ecuador's WebApp ("ECU") is found at http://ohi-science.org/ecu. Each WebApp displays data layers*, which are raw data in this case, as well as the calculated OHI scores based on information extracted from global assessments. As such, they do not provide fine-scale resolution of data for each coastal nation or territory: the scores and data on which they are based are a starting point for an assessment to be conducted by an independent group. These data

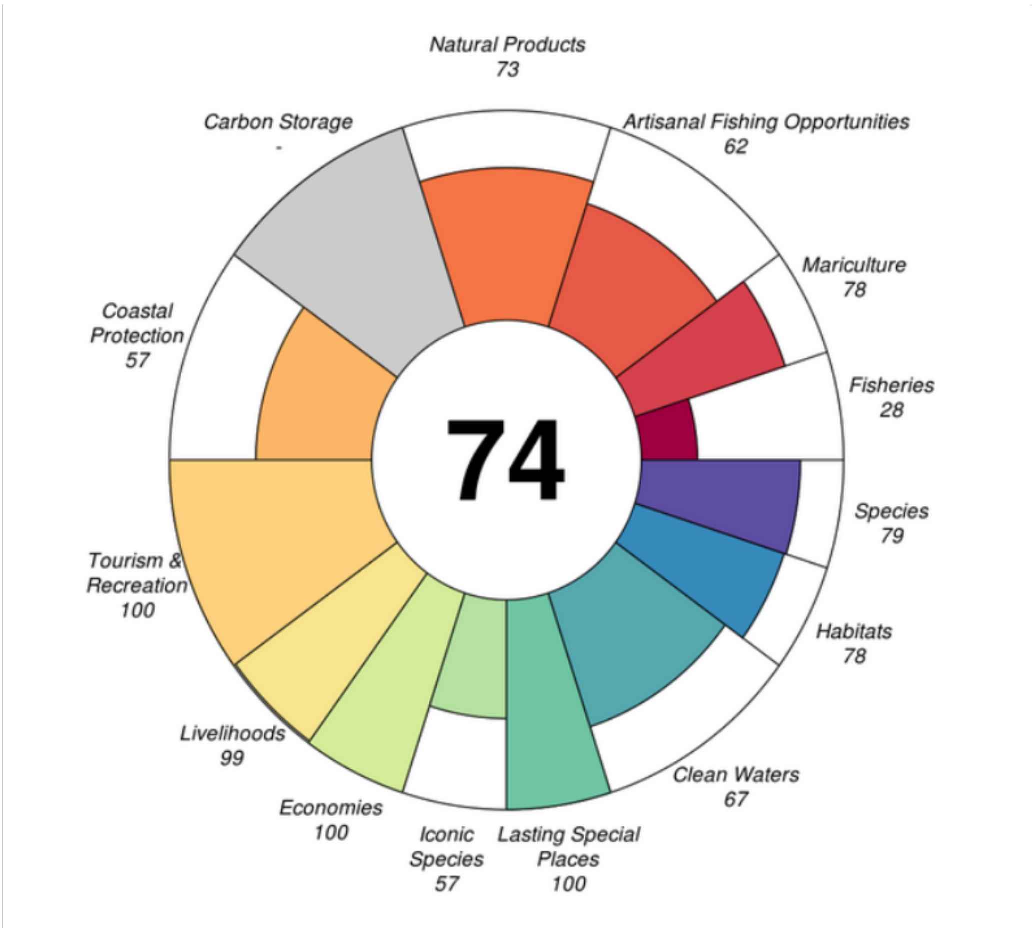


Figure 2: Scores for Ecuador (ECU) as displayed in a flower chart on the the OHI WebApp. The length of a petal indicates the score for the goal or sub-goal, and the width of the petal indicates the goal or sub-goal weighting.

can be used as a default if better data for the region do not exist, but we encourage you to replace them wherever possible. (*Note: each data component that is included in the OHI is called a **data layer** because it will be combined with others to calculate the goal scores. Many data layers are rescaled from 0-1 to be combined with other data layers on the same unitless scale.)

Boundaries for exclusive economic zones (EEZs) were identified by http://www.marineregions.org and the largest subcountry regions (i.e., provinces, states, districts) were identified by http://gadm.org. Subcountry region boundaries were extended offshore to divide the EEZ of each study area into offshore regions. These subcountry regions have been provided as a starting point, and are typically coastal states or provinces, which, in our experience, is consistent with the scale at which most policy decisions are made. However, it is possible to change the boundaries for the regions and the study area depending on your preferences.

OHI WebApps serve several purposes because they:

1. allow for exploration of how the Index works: what data look like and which data layers are used in each goal
2. are a communication platform for an assessment team, since information is presented in a manner that is accessible to group members of different disciplines and technical capacities
3. can be used to set data gathering or goal model development priorities for the assessment
4. display your assessment's data and calculated scores once you have finalized and formatted your data and modified goal models.

The information displayed on the website is stored online, in a **GitHub repository.** GitHub is an open-source development platform allows for multiple users to collaborate, track changes, and document work such as data files and code. Therefore, any changes made to the files contained within the GitHub repository will be displayed on the WebApp for all team members to view. See below for how to modify files using GitHub.

3.2 Using the WebApp

When first exploring a WebApp (for example, http://ohi-science.org/ecu), first note that it is possible to **translate** the site into any language that Google provides using the pull-down menu at the top.

The WebApp homepage provides several tabs for you to explore. The interactive **App** sub-page allows you to explore input data layers and output calculated scores for each region (See **Overview of Variable Options**). More detailed information is about the default **regions** and **data layers**, **goal models**, and **calculated scores** based on global data can be viewed in separate tabs, as well as through the App page. A quick reference about navigating the WebApp is available through the **Docs** link at the bottom of the page. When your team has finalized data layers and updated goal models, these data and scores will be visualized through the WebApp.

3.3 The App Page

The App page allows you to explore and visualize input data layers and calculated output scores for each region in the study area. By default, global data are presented for each subcountry region in the study area, and scores are calculated for each region using those data.

The App page displays this information through two tabs: Data and Compare. The **Data** tab provides several subtabs for viewing data (*Map*, *Histogram*, *Table*), and is the default tab when the Toolbox is launched. The **Compare** tab is most useful for comparing output scores when modifications are made to the underlying data or models (this provides a way to error check) once you have begun the process of calculating your own assessment.

The App provides two Branch/Scenario options to view, identified in the upper-left corner of the Data tab. The **Branch** options refer to the versions of the GitHub repository where data are stored. Branches start off

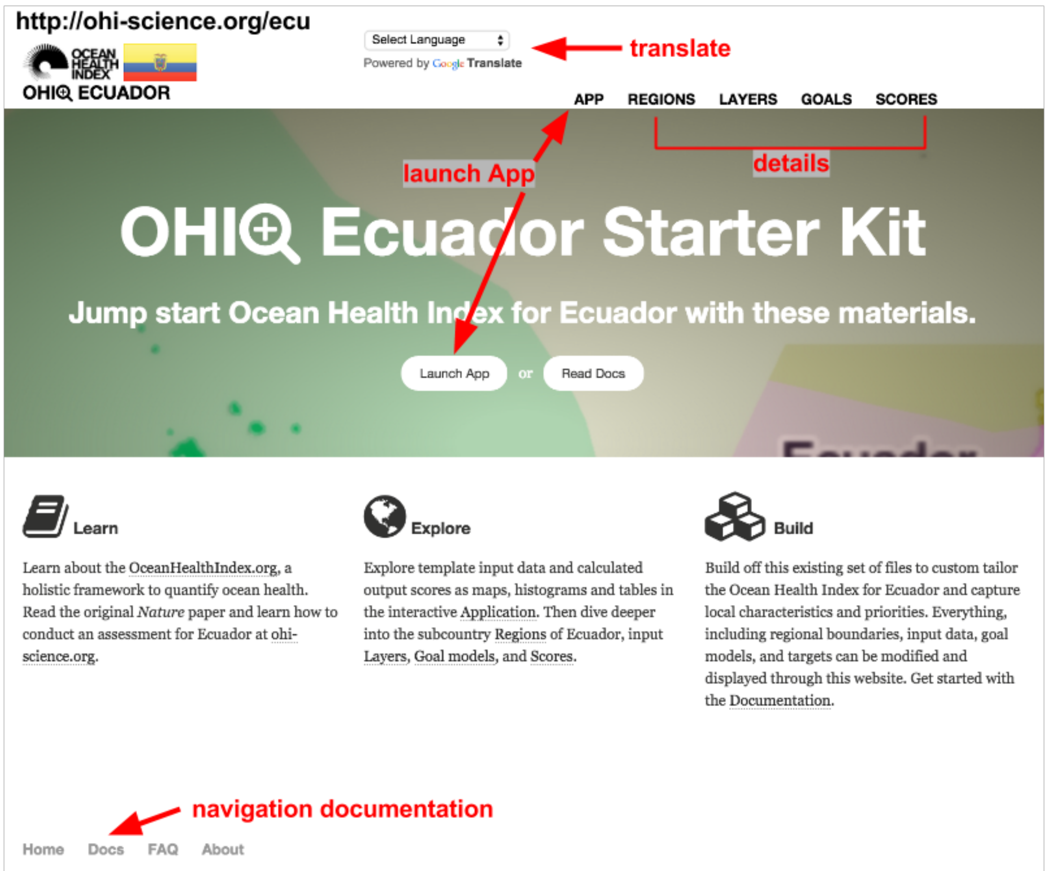


Figure 3: The WebApp start page. Note that it's possible to translate the page into your language of choice.

as copies of the same repository, but can be modified independently of each other, enabling progress to be made on one ('draft' branch) while not altering the vetted original ('published' branch). These branches can be merged back together at any time. The App page will display the 'published branch' by default; we recommend working on the 'draft' branch until your assessment is finalized, at which point you would merge the draft branch with the published branch.

Scenario folders contain all the files needed to calculate scores. Scenario folders can differ from each other based on the years included (i.e., 2014 would be a different scenario from 2015), or they can be used to explore outcomes of policy alternatives, such as implementation of a proposed Marine Protected Area network or fisheries regulations.

3.4 The App's Data tab

3.4.1 Overview of display options

The Data tab displays input data layer or calculated scores for each goal parameter, and presents the information as a map, histogram, or table. These options (*Map*, *Histogram*, *Table*) are presented as subtabs located the map. The Map subtab is the default display option for the Data tab, and all data presented are based on data from global assessments.

Data displayed in the Map subtab:

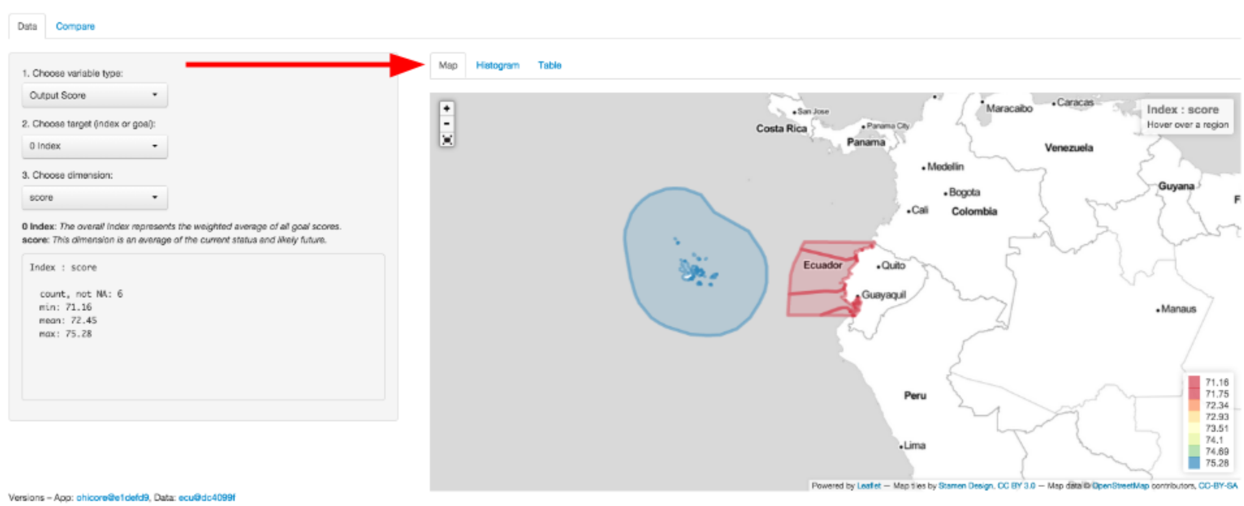


Figure 4: The Map subtab. Click on 'Map' to see a geographic view of your assessment region. Colors indicate scores or values for your input layers or output scores.

The map displays data for every region as reported in the scenario. A color legend is displayed in the lower right corner of the map. The range of values will change as different variables are selected, and the colors will automatically change to create a visual scale of reference.

Data displayed in the Histogram subtab:

The histogram shows the distribution of the selected variable as the number of observations per value bin (white bars) and a smoothed density function (pink shading).

Data displayed in the Table subtab:

The table displays the target value for each region and the overall study area. It provides an identifying code (*rgn_id*), name (*rgn_name*), and value (*value*) for each.

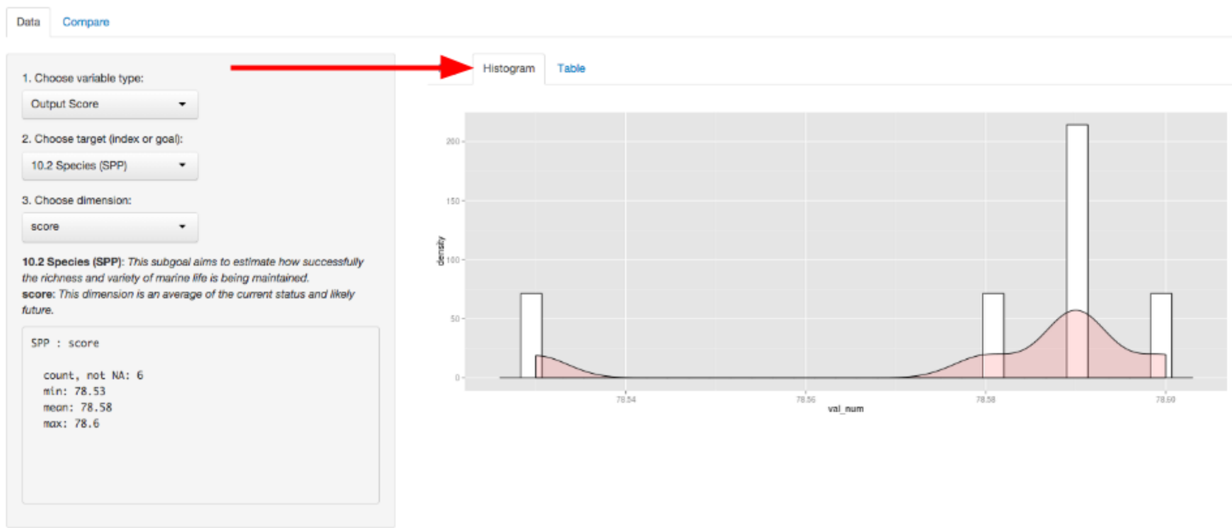


Figure 5: Click on 'Histogram' to see the distribution of your data or scores, after selecting a variable layer on the left. This example shows the Species sub-goal scores for the study regions of Ecuador.

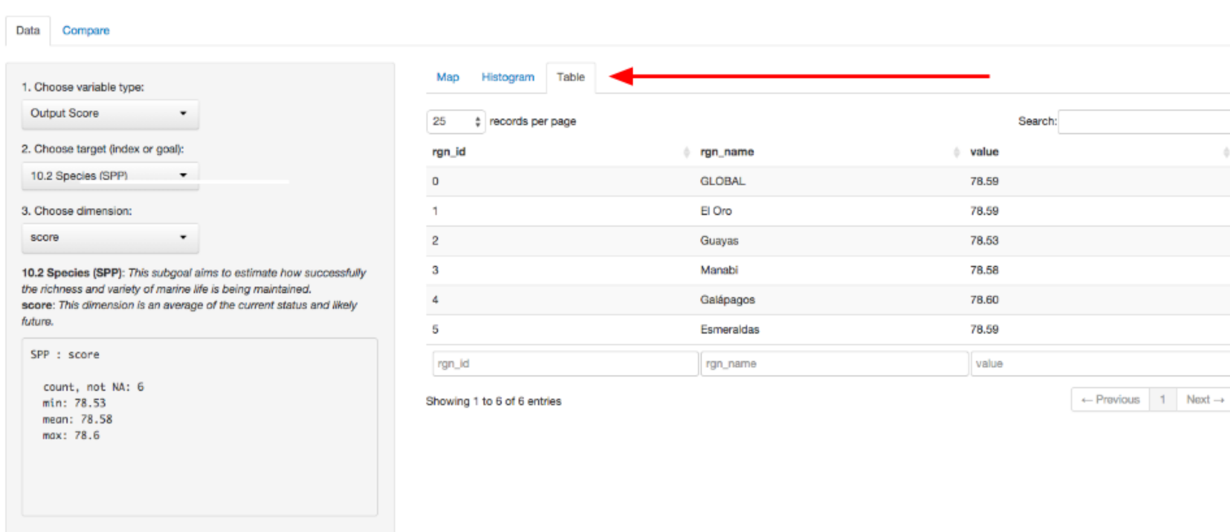


Figure 6: Click on 'Table' to see a table of your data or scores, after selecting a variable layer on the left. This example shows the Species sub-goal scores for the study regions of Ecuador.

3.4.2 Overview of variable options

The Data tab has drop-down menus from which you choose the data to be displayed. Data selected from the pull-down menus can be viewed in Map, Histogram, or Table form as described in the section above. Descriptions, statistics and metadata for the chosen fields are also displayed below the drop-down menus on the left side of the tab.

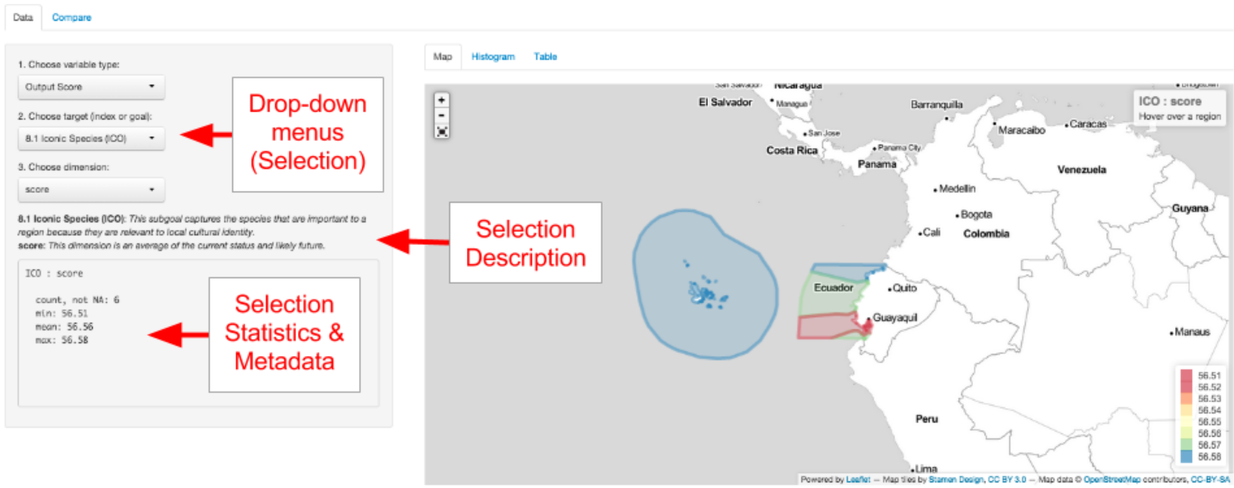


Figure 7: Overview of the Data tab. Choose the variable you would like to explore through the drop-down menus on the left-hand side of the page. Once you select either raw data or a score, you can view a description and statistical summary below.

> TIP: Remember that your descriptions and values in `layers.csv` will appear here.

The first selection to be made from the drop-down menus is variable type, in which you can choose the **Output Score** that will show a calculated score (for a particular target chosen subsequently), or **Input Layer** that will show the data layer used to calculate the score of a particular target. To reiterate, Output Scores are the scores calculated using the Input Layers (data layers).

For example, if you select 'Output Score' as the variable type (which is the default), you will then be able to choose a target (goal or sub-goal), and the OHI dimension to be reported.

As another example, if you select 'Input Layer' as the variable type, you will be able to choose a target and a specific data layer associated with that target. If that layer has multiple categories or years available, you will be able to select a preference. Without selection, the default setting is the first category alphabetically and the most recent year.

3.5 The App's Compare tab

The **Compare** tab allows you to compare differences in calculated scores based on changes you have made to the underlying data layers. Visualizing these differences is extremely helpful for confirming results and error checking. More context on the use of this function can be found in the section, "**The Ocean Health Index Toolbox**."

3.6 Before conducting an assessment

> **Section Summary:**

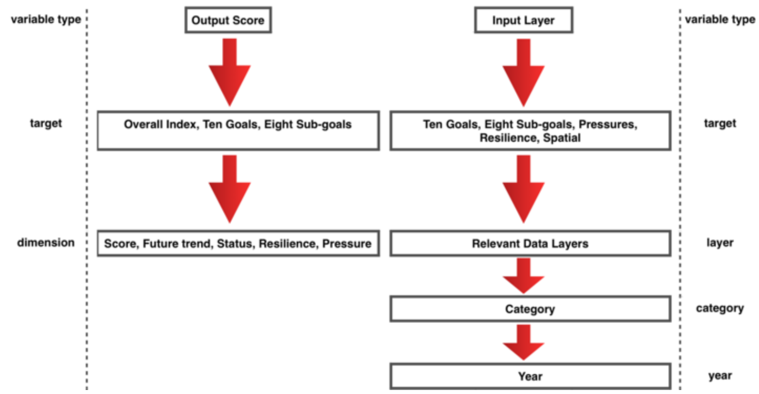


Figure 8:

This section advises you on how to plan for a successful assessment. From engaging decision-makers early on, to maintaining future assessment efforts, here are some key points to consider.

Before conducting an assessment, it is important to prepare the following:

- Develop a strategic plan and timeline
  - establish the need for an assessment
  - define the spatial scale of the assessment: country, state, eco-region, etc.
  - determine the resources available
  - outline a timeline with necessary meetings and workshops
  - engage decision-makers early for results to be most useful
- Assemble a qualified team with diverse skills and knowledge, including:
  - a broad scientific understanding and experience with environmental policy
  - ability to manage large data sets, make decisions, and think creatively
  - capacity to collaborate in a multidisciplinary team, remotely and in person
  - team members who can use the statistical programming language R (http://cran.r-project.org/), ArcGIS or other spatial analysis software, and are fluent in English
- Funding
  - greatly depends on the local context
  - potentially needed for a management and scientific team, workshops and meetings (including travel), communications, policy engagement, and operating costs
- Policy and management interest
  - engage decision-makers early: informing policies to improve ocean health is most effective if there is early interest and engagement from government agencies and decision-making bodies
  - requires ongoing communication during Index development to best inform management actions
  - repeated assessments as new data become available enable tracking ocean health through time and evaluating management and policy interventions

4 Conducting an Assessment

Section Summary:

In this section, you will learn what to think about before conducting an assessment. Your team should already be familiar with the OHI approach and can now prepare for tailoring it to the local context.

TIP: Careful planning before an assessment will pay off later.

4.1 What to expect when conducting an assessment

There are key considerations and processes that will be a part of every assessment, however, the process for conducting each assessment will be unique depending on the local context. For example: what data and indicators are available will determine how goal models can be tailored to the region, and what skillsets and resources are involved will affect the time it takes to complete the assessment.

4.1.1 Timeline

The time required to complete an assessment depends on the local context and available resources, but the proportion of time required for different phases of the assessment is more predictable.

Expect strategic planning, discovering and gathering data, and developing reference points and models to comprise > 80% of the time allotted for the assessment.

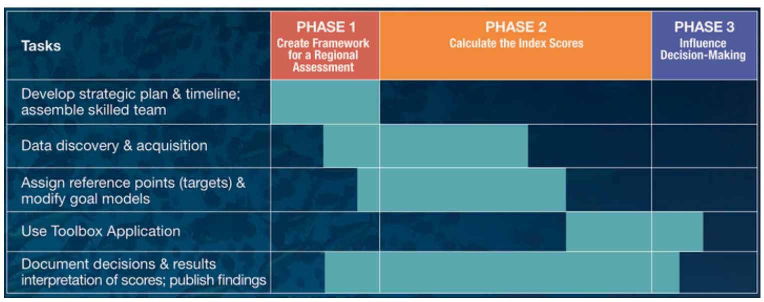


Figure 9:

4.2 Where to start

You should start by understanding the structure of the global assessment and the data involved will help you think about what should be done differently in your local context.

The best way to do this is to begin with the WebApps. As described in the section, "**Overview of the OHI WebApp**," most coastal countries have a WebApp that was created to facilitate planning and communication during your assessment. The WebApp presents data, goal models and calculated scores for each region (global administrative area identified by http://gadm.org) visually through maps, histograms, and tables. All data presented were extracted from the global analysis, and scores were calculated using global goal models. For a finer-scale assessment of ocean health in your region, these data files provided will need to be updated with available data and indicators for each region in your assessment. However, if better data are not available, you can use the data provided. Then, to dive deeper into data layers and goal models, you can explore your assessment's GitHub repository, which stores all the information presented through the WebApp.

You should also be familiar with the approaches taken by other assessments adapted from the global context, including Brazil, the US West Coast, and Fiji. You can find these studies at http://ohi-science.org.

While our team of scientists and managers is prepared to provide guidance for assessments, you should follow the steps in this training program to complete your assessment as autonomously as possible.

4.3 Points to remember

We recommend keeping in mind the following as you develop your approach:

- People are part of ocean health
  - economic and social data are included in OHI: consider how people are locally engaging with the ocean
- Goal models should be modified to capture local characteristics and priorities that can be measured with available data
  - after identifying what is important locally, identify direct or indirect measures to develop tailored goal models

- Assessments can use a mix of regional-, country- and global-scale data
  - include the finest-scale data available, but when this is not possible, rely on global-scale data
- Scores are calculated by region and then aggregated to the study area
  - comparing scores between regions is a primary reason for conducting a independent assessment
  - goal models and data layers are the same across all regions; data values will vary by region. For example, the carbon storage goal model is the same for each region, but the habitats present in each region, and the area and condition of those habitats (the data values) are specific to each region
- All data do not need to be at the same spatial or temporal scale
  - each assessment should represent the best understanding of ocean health at a point in time. For example, if fisheries data are available from 1980-2011 and tourism data are available from 2008-2012; these can both be used to represent current ocean health
- Document all decisions made, including:
  - all data sources (publications, website URL, date of access, etc).
  - processes for establishing reference points,
  - how and why models were modified, and additionally why other potential modifications were not done, as this reminds yourself of past decisions and helps explain them to others in the future)
  - that it is important for transparency, describing methods and explaining results in reports and publications, and for reproducibility (for any future comparable assessments in your study area)

4.4 Checklist: How to prepare for using the Toolbox

Most time spent conducting an assessment occurs before using the Toolbox to calculate scores. Prior to these calculations the Toolbox and WebApp can be used to understand the Index and as a tool to provide structure to its underlying framework. For example: how the data and models are used to calculate the ten goals (and, in some cases, corresponding subgoals) for each region and how these are combined to generate an overall score for each region can be explored with the Toolbox. At this point, the Toolbox provides a guideline for the data that must be collected and how it should be organized.

When going through the checklist remember too that a motivation for conducting an assessment is to be able to modify goal models and set reference points using finer-scale, local information and reference points.

The following list of tasks will not necessarily be accomplished in sequence: there is a lot of iteration of tasks as you discover data, develop reference points and models, and revisit other data possibilities. This checklist identifies decisions and steps that must be done before the Toolbox can be used to calculate your goal scores:

- Understand the philosophy of OHI
  - what the goals represent, how they are modeled, and what types of data are included
  - what pressures and resilience data are included
  - how reference points are set
- Identify local characteristics and priorities
  - what local cultural preferences or priorities should be captured in the assessment?
  - should any goals be removed?
  - should any goals be redefined?
  - should other goals be added?
  - should goals be weighted unequally?
  - what are social and ecological pressures to the local system?
  - what social and ecological resilience measures (laws, regulations, restoration projects) are in place locally?
- Be familiar with the global inputs (data and models) used in the WebApp
  - understand the data and models used in global assessments
  - prioritize which data and models should be updated to better represent local characteristics and priorities
- Decide the spatial scale for regions within the study area
  - do the WebApp regions (states or provinces) make sense? If not, what alternate scales are more appropriate?
  - we recommend multiple regions to allow for comparisons and determine geographic priorities within the study area
  - regions should be at the smallest scale the data allow
  - at what spatial scale are data most frequently reported?
  - at what spatial scale are policy decisions made (optional)?
- Discover and gather appropriate data and indicators
  - what local data and indicators are available for goal models?
  - what local data and indicators are available for pressures and resilience?
  - are available data and indicators relevant to OHI?
  - are local data and indicators at the appropriate temporal scales?
  - how should reference points be set for local data?
  - process and format data and indicators to create data layers for the Toolbox (See 'Formatting Data for the Toolbox' section below)
  - use the Toolbox repository as a registry to organize data layers
- Update pressures and resilience information
  - determine whether all global pressures are relevant locally
  - identify local pressures not captured in the global pressures matrix
  - categorize any new local pressures layers
  - set pressure weighting/ranking based on literature, expert opinion
  - identify potential resilience measures for each of the pressures identified
  - determine what datasets may be available to measure resilience metrics
- Modify goal models mathematically:
  - how can goal models be represented mathematically using locally available data and indicators?
  - can reference points be refined using locally available data and indicators, government mandates, management targets, obligations from multilateral agreements?

4.5 Discovering and Gathering Appropriate Data and Indicators

The OHI spans disciplines and integrates diverse data to give a comprehensive assessment of ocean health. A hallmark of the OHI is that it uses freely-available, existing data and indicators to create models that capture the philosophy of individual goals, and finding appropriate data requires good problem-solving abilities. There are many decisions to make when gathering from disparate sources, identifying good proxies and indicators, deciding reference points, and developing goal models.

** The accuracy of Index scores is a reflection of input data quality and the degree of understanding of the study area, and thus including the best quality and appropriate data and indicators available is of highest importance.**

Because the data and indicators you use will come from different sources and available from online databases, reports, spreadsheets and text files, they will also have different formatting. To include these data and indicators in your assessment, you will need to process these files into the format required by the Toolbox, which is explained in the section, **Formatting Data for the Toolbox**. When data have been prepared and formatted for the Toolbox, we call it a **data layer.** Because creating data layers can be quite time-intensive, data should only be prepared for the Toolbox after final decisions have been made to include the data or indicator in your assessment, and after the appropriate goal model and reference points have been finalized.

There are many data layers included in the OHI framework. There are about eighty individual data layers from the global assessment that should be replaced with higher-resolution data in your study area where possible. You will need to search for data used to calculate status models as well as pressures and resilience layers.

4.5.1 Data sources

Existing data and indicators can be gathered from many sources across environmental, social, and economic disciplines, including:

- government reports and project websites
- peer-reviewed literature
- masters and PhD theses
- university websites
- non-profit organizations

All data must be rescaled to specific reference points (targets) before being combined with the Toolbox; therefore setting these reference points at the appropriate scale is a fundamental component of any OHI assessment. This requires your assessment team to interpret the philosophy of each Index goal and sub-goal using the best available data and indicators. Some indicators already are scaled (e.g., from 0-1 or 0-10), and can easily be incorporated into your assessment since the reference points have already been identified.

4.5.2 Gathering responsibilities

Gathering appropriate data requires searching for and accessing existing data. You do not have to go collect the data itself, but you do need to discover and acquire existing data. It is important that team members responsible for data discovery make thoughtful decisions about whether data are appropriate for the assessment, and that they get feedback from the full team to discuss the merits of different data sources. Data discovery and acquisition are typically an iterative process, as there are both practical and philosophical reasons for including or excluding data.

When you begin exploring data possibilities, you can seek local data sources that could directly replace data from the global assessment provided in your repository. Such data would be better quality, i.e., higher accuracy and spatio-temporal resolution, than the data from the global assessment, and models may not need to change. However, we recommend first exploring other data possibilities that could capture specific characteristics to your study area. Assessments conducted at smaller scales are an opportunity to include characteristics specific to your study area that were not captured in the global assessment.

4.5.3 The process of discovery

The most important thing to remember when gathering data and indicators is that they must contribute to measuring ocean health. Not all information that enhances our knowledge of marine processes directly convey information about ocean health and may not be appropriate within the OHI framework. Because of this, compiled indicators can sometimes be more suitable than raw data measuring single marine attributes.

Begin by understanding and comparing the best approaches used in assessments that have been completed, including global assessments, Brazil, Fiji, and the US West Coast. For the smaller-scale assessments (i.e., anything but the global assessments), if finer-resolution local data were available in the study area, these data were either incorporated into modified goal models that used locally appropriate and informed approaches or into the existing global goal model. When local data were not available, the global-scale data and global goal models were used, which is least desirable because it does not provide more information than the global study. When looking for data, the following decision tree may be useful. This should be a goal-by-goal process:

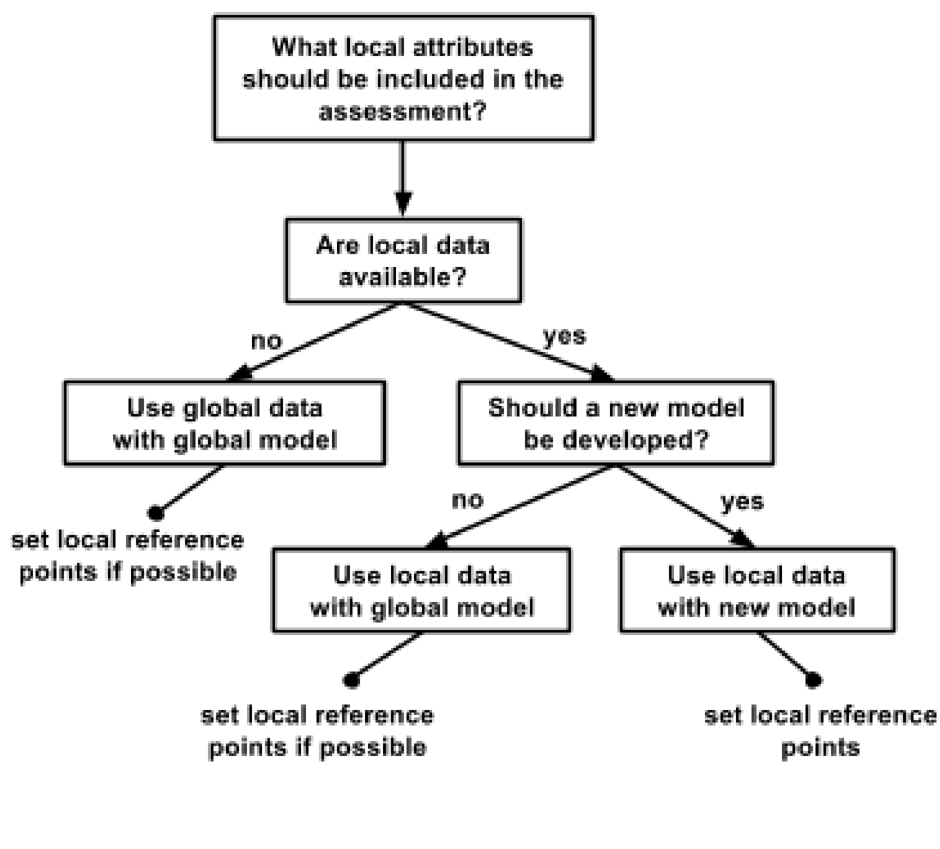


Figure 10:

4.5.4 Requirements for data and indicators

There are six requirements to remember when investigating (or 'scoping') potential data and indicators. It is important that data satisfy as many of these requirements as possible, at times requiring gap-filling solutions.

If requirements are not met and gap-filling solutions are not possible, you will likely need to exclude a dataset from the analyses. If data cannot be included, you may elect to use the global data layers or identify other data and a different modeling approach.

1. relevance to ocean health
2. accessibility
3. quality
4. how to set the reference point
5. spatial scale
6. temporal scale

4.5.4.1 Relevance to ocean health There must be a clear connection between the data and ocean health, and determining this will be closely linked to each goal model.

4.5.4.2 Accessibility The two main points regarding accessibility are whether the source is open access and whether the data or indicators will be updated regularly.

The Index was created in the spirit of transparency and open-access, using open-source software and online platforms such as GitHub, is to ensure as much accessibility and open collaboration as possible. Data and indicators included should also follow these guidelines, so that anyone wishing to understand more about the Index may be able to see what data were used and how. For this reason we emphasize the importance of using data that may be made freely downloadable, as well as the importance of clearly documenting all data sources and reasons for the choices made in selecting data, indicators, and models.

Index scores can be recalculated annually as new data become available. This can establish a baseline of ocean health and serve as a monitoring mechanism to evaluate the effectiveness of actions and policies in improving the status of overall ocean health. This is good to keep in mind while looking for data: will it be available again in the future? It is also important to document the sources of all data so that it is both transparent where it came from and you will be able to find it in the future.

4.5.4.3 Quality Understanding how the data or indicators were collected or created is important. Are they collected by a respected organization with quality control? Are there any protocol changes to be aware of, e.g., were there changes in the collection protocol to be aware of when interpreting temporal trends?

4.5.4.4 Reference point Most data will need to be scaled to a reference point, as you consider different data sources it is important to think about or identify what a reasonable reference point may be. Ask the following types of questions as you explore data possibilities:

- Has past research identified potential targets for these data?
- example: maximum sustainable yield in fisheries
- Have policy targets been set regarding these data?
- example: maximum levels of pollutants before beach closures
- Would a historic reference point be an appropriate target?
- example: percent of habitat coverage before coastal development
- Could a region within the study area be set as a spatial reference point?
- example: a certain region a leader in creating protected areas

4.5.4.5 Appropriate spatial scale Data must be available for every region within the study area.*

4.5.4.6 Appropriate temporal scale

Data must be available for at least three to five years to calculate the trend. For some goals, where temporal reference points are desirable, longer time series are preferable.*

* It is not always possible to fully meet the spatial and temporal requirements with each source. In these cases, provided that the gaps are not extensive, it can still be possible to use these data if appropriate gap-filling techniques are used (See: ‘Formatting Data for Toolbox’ section).

4.5.5 Example: US West Coast data discovery

Below are examples of some decisions made when exploring available data for the US West Coast assessment. Determining whether certain data could be included began with a solid understanding of the data layers and models included in the global assessment. Since the US West Coast is a data-rich region, finer-resolution local data could be used in place of many of the global data layers. The US West Coast assessment had five regions: Washington, Oregon, Northern California, Central California, and Southern California.

4.5.5.1 Reasons data were excluded

There are a lot of existing data that contribute to our scientific understanding of ocean processes and interactions but are not ideal for the OHI. Reasons to exclude data are both due to practical requirements (e.g., resolution, coverage, or other requirements that have been listed) and philosophical requirements (i.e., they do not help capture the attributes of interest for assessing ocean health). Some common reasons for excluding data are:

- **The data do not cover the entire area of the reporting region**. The state of California had excellent, long-term data on public attendance at state parks that would have been quite useful in the calculation of the tourism and recreation goal. However, data were only available for three of the five regions (the three California regions but not Oregon and Washington), so they could not be used.
- **There is not a clear and scientifically observed relationship between the data and ocean health**. Along the US West Coast, kelp beds are a very important habitat because of their contribution to biodiversity and coastal protection. However, kelp coverage variation and is driven primarily by abiotic natural forcing (wave/storm disturbance and temperature) and thus it is not a good indicator of kelp forest health, particularly in the case of anthropogenic impacts. For these reasons kelp coverage was not included in the assessment.
- **The feature being measured may provide benefits to people, but this feature is not derived from marine or coastal ecosystems**. Sea walls and riprap provide coastal protection to many people along the US West Coast. However, these structures are not a benefit that is derived from the marine ecosystems, so only coastal habitats were included in the calculation of this goal. These data can be included as a pressure due to habitat loss. They were not used as a resilience measure because they can often have negative side effects (e.g., by altering sedimentation dynamics), and because they have limited long-term sustainability (i.e., they need maintenance).
- **Data collection is biased and might misrepresent ocean health**. The US Endangered Species Act identifies a species list focused on species of concern within the US. As such, these data are biased in the context of ocean health since they only assess species whose populations may be in danger. For the calculation of the biodiversity goal, using these data would be inappropriate because this goal represents the status of all species in the region, not just those that are currently of conservation concern. Using these data may have shown the status of biodiversity to be lower than it really is because the selection of species to assess was already biased towards species of concern.
- **Time series data are not long enough to calculate a trend or a reference point** (when a historical reference point is most appropriate). For the US West Coast, the current extent of seagrass habitats was available, however, these do not exist for previous points in time in most areas, so could not be used to calculate the trend or set a historical reference point. Therefore, we estimated the trend in health of seagrass habitats using as a proxy the trend in the main stressor (i.e., turbidity). In other

words, we assumed that the rate of seagrass loss was directly proportional to the rate of increase in turbidity. Similar solutions may be used to estimate trends in your own assessment, if there is scientific support for assuming that the trend of what we want to assess (or the relationship between the current state and the state in the reference year) has a strong relationship with the trend of the proxy data available.

4.6 Pressures and resilience

Pressures and **Resilience** are two of the four dimensions used to evaluate each goal or sub-goal (the other two are **Status** and **Trend**).

- **Pressures** are the sum of the ecological and social pressures that negatively affect goal scores.
- **Resilience** is the sum of the ecological and social status (e.g., food-web integrity, health of the governance process) and initiatives (e.g., environmental laws, social policies) that can positively affect goal scores by reducing or eliminating pressures.

It is important to identify the pressures that affect the ocean and coastal systems in your study area, as there will likely be additional pressures not included in the global assessments. Once you have identified pressures within your study area, you should identify what resilience measures could counteract or nullify those pressures.

The same considerations and requirements about data presented in the "**Gathering Appropriate Data**" section also apply to pressures and resilience. Every measure you include for pressures and resilience requires data for each region in your assessment. This is explained in more detail in the following sections.

In the figure below, likely future state (in yellow) is the result of the current status modified by trend, minus the negative effect of pressures (grey), plus the positive effect of resilience (salmon pink).

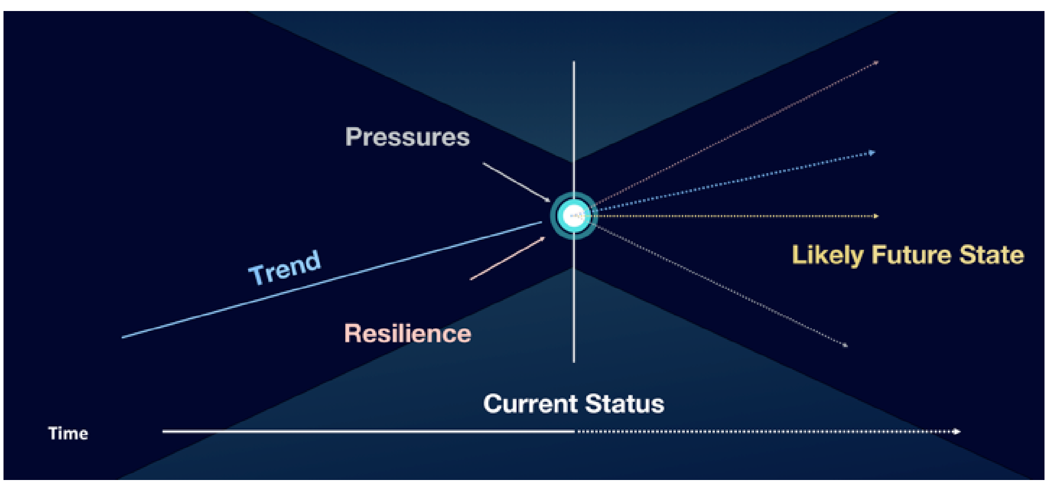


Figure 11: In the figure, likely future state (in yellow) is the result of the trend, minus the negative effect of pressures (grey), plus the positive effect of resilience (salmon pink)

4.6.0.2 Pressure and resilience categories The Toolbox calculates pressures in five ecological pressure categories (pollution, habitat destruction, fishing pressure, species pollution, and climate change) and one social pressure category. The reason behind the ecological categories is to avoid hidden weighting (e.g. overrepresentation of pressures for which there is more data). For example, in the global assessment there were many pollution datasets available, but few distinct habitat destruction datasets. If we simply averaged the scores of each individual stressor, pollution scores would have a greater influence on the results (stronger weight) due to the relative higher availability of measurements of various pollutants. Instead, aggregating by pressure categories ensures that different stressor types influence the score based on ranks. Nonetheless, the scores are combined in a cumulative way within each category to account for the fact that multiple stressors within a category have a cumulative impact that is greater than if only one of the stressors were present. The resulting scores for the five ecological categories are averaged to produce a single ecological pressures score. This score is then averaged with the social pressures score to produce the final overall pressure score.

Ideally, every stressor with an identified strong impact should have a corresponding resilience measure. The rationale is that as resilience in the study area increase (example: by improving regulations), the pressures would decrease and overall scores would increase. It is important that resilience measures 'balance' or neutralize the pressures, so the regulations are effective in keeping the stressor(s) under control. By including a regulatory response to each pressure affecting the optimal delivery of the goals, you ensure that the resilience regulation measures are relevant to ocean health.

In practice, however, the pressures and resilience measures you include in your assessment will be highly determined by data availability. It is best to first consider what pressures are acting in your study area and then determine if data are available to measure them. You should also decide if the pressures data included in the global assessment are relevant for your assessment and determine if local data better better capture pressures for the study area (and the reporting regions). When considering resilience measures, look for regulations or indicators that could be encompassed in one of the pressures categories.

The figure below shows stressors by category, and the resilience measures meant to 'balance' (or counteract) them for the global assessment. Note that resilience layers are only available for some categories and goals. Also, some resilience measures are goal-specific; that is, they act on certain goals without counteracting pressures. When you have regulations to improve the practices captured in the status specific goals (e.g. sustainable tourism, lower bycatch, etc.), you can include them as resilience measures.

4.6.0.3 Pressure and status interactions Goals interact with each other because the pressure created by one goal may affect another goal. For example, cultivating fish for mariculture (food provision sub-goal) can cause genetic escapes threatening the health of wild fish populations. This pressure affects two sub-goals: wild-caught fisheries and species, but does not affect the mariculture goal itself. In other cases, such as the fishing harvest pressure, the pressure comes as a result of pursuing the food provision sub-goal of wild-caught fisheries, affecting several goals including the fishing sub-goal itself.

4.6.1 Pressures and resilience matrices

After you identify the pressures and resilience measures for your study area are and gather available data for each region, you will use matrix tables to determine how each of the measures affects each goal and sub-goal (for some goals you will also need to do this for habitat type or natural product categories). The pressures matrix establishes the relationships between stressors and goals are determined, and uses a rank from 1-3 to weight how strongly a given pressure affects a goal or sub-goal relative to all the other pressures affecting it.

The rank weights used in the pressures matrix were determined by Halpern *et al.* 2012 (*Nature*) based on scientific literature and expert opinion (see Supplemental Table S28 of *Halpern et al. 2012*). In the pressures matrix ranks are categorized as follows:

- 3 = high pressure
- 2 = medium pressure
- 1 = low pressure

Stressors that have no impact are not included rather than being assigned a rank of zero, which would affect the average score. Pressures are ranked rather than being represented as a binary (yes/no) measure

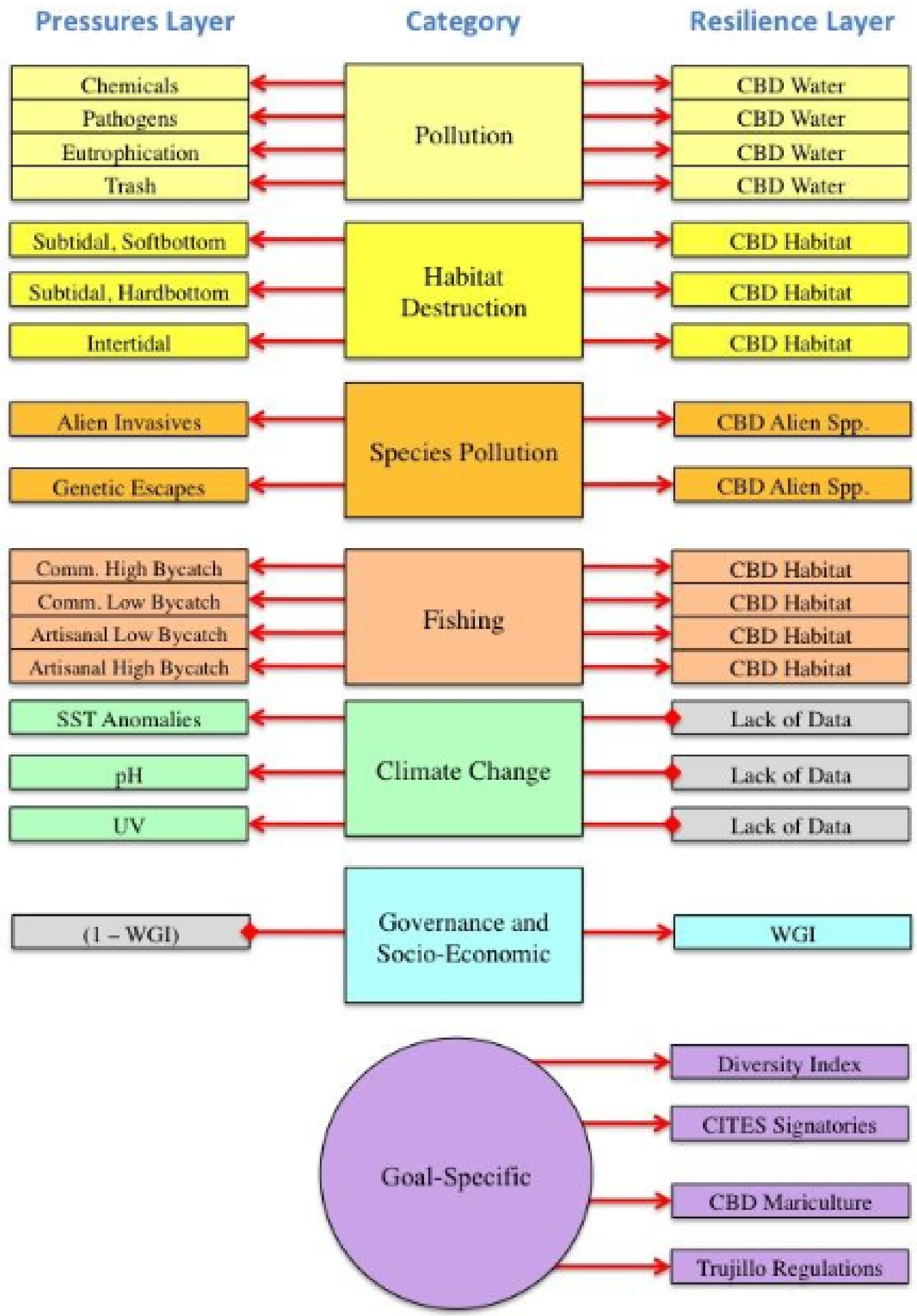


Figure 12: Each resilience data layer should have a corresponding pressures layer, and vice versa. Note that a pressure layer becomes (1-resilience) in cases where only resilience data are available, due to data limitations.

because the range of consequence of different pressures on each goal can be quite large, and to classify all those pressures as a simple ‘yes’ would give too much influence to the weakest stressors. For example, food provision is most heavily impacted by unsustainable, high-bycatch fishing, but pollution does have some impact on fish populations. Without a weighting system, these stressors would be treated equally in their impact on the food provision goal.

	Pollution Pressures Data Layer 1	Pollution Pressures Data Layer 2	Pollution Pressures Data Layer 3	Fishing Pressures Data Layer 1	Fishing Pressures Data Layer 2	Climate Change Data Layer 1	Climate Change Data Layer 2	...
FISHERIES (Food Provision)	1			1			2	2
MARICULTURE (Food Provision)	2				3			
ARTISANAL FISHING OPPORTUNITY		1			1		1	3
CARBON STORAGE Habitat 1		1			1			
CARBON STORAGE Habitat 2		1			2			
CARBON STORAGE Habitat 3		2			3			
...	...	...	...	...	...	...	...	...

Figure 13: Scores from 1-3 are given to rank the importance of each pressure. Only values of 2 or 3 require that a resilience layer be activated when calculating the goal scores.

While pressures and resilience are usually displayed as two-dimensional matrices, they are actually three-dimensional matrices: each stressor should have data for each region in the study area, which is the third dimension of the matrix, as shown in the figure. The Toolbox will combine the data with the rank weights to calculate the pressures scores. Therefore, pressure weights should not be applied to the regions, but only to the goals. The Toolbox will multiply the stressor score for each region by the weight (1, 2, 3) assigned to that pressure for a specific goal and subgoal, and then it will combined that score within its appropriate pressure category as previously discussed.

Each pressure with a rank weight of 2 or 3 should have a corresponding resilience measure, which is meant to ‘balance’ the pressures since these have the greatest effect on ocean health. The Ocean Health Index considers resilience in two categories: **ecological resilience** to address ecological pressures, and **social resilience**, which may not be strictly marine-related, but they can help estimate how a region may be able to respond to or prevent new environmental challenges. Additionally, **goal-specific regulations** are intended to address ecological pressures, and are measured as laws, regulations, and other institutional measures related to a specific goal. Ideally, for any resilience measure, you would have three tiers of information:

- **Existence of regulations**: Are regulations in place to appropriately address the ecological pressure?

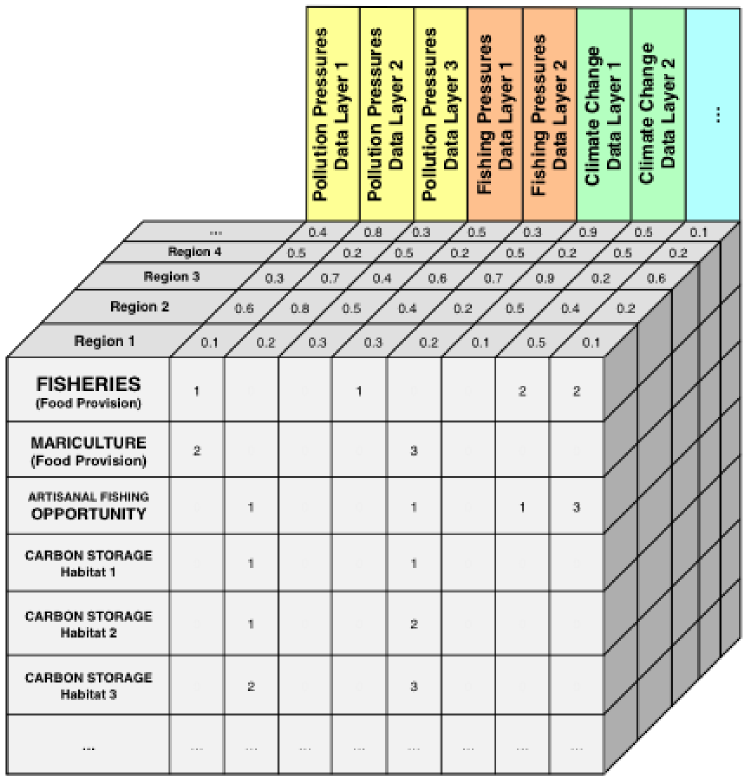


Figure 14: The pressures matrix is three-dimensional: each pressure layer has data per region, which is multiplied by the ranking weights of the pressures matrix.

- **Implementation and enforcement**: Have these regulations been appropriately implemented and are there enforcement mechanisms in place?
- **Effectiveness and compliance**: How effective have the regulations been at mitigating these pressures and is there compliance with these regulations?

Ideally, information would exist for these three tiers, and you would be able to weight the resilience measure based on the quality of the information as 1 (existence of regulation), 2 (implementation and enforcement), or 3 (effectiveness and compliance). This approach is different from the way ranks are assigned in pressures, which is based on impact. However, in most cases, information is not available for these three tiers: often, the existence of regulations is all that is available, and this does not always vary by region. In some cases, you may want to consider building your own set of indicators to determine **implementation and enforcement** and **effectiveness and compliance.**

4.6.2 Incorporating local pressures in your assessment

The pressures you will include in your assessment will depend on what is important in your study area and what data are available. If local pressures data are not available, you may default to using data from the global assessment, but this means in most cases that you will not have different information for each region (we will discuss this in more detail later). You will determine the weight ranks required in the pressures matrix only after you have identified the data you will include.

The following steps outline the process of how to include pressures in your assessment. The steps are iterative; return to previous steps to ensure you capture all important pressures in your study area:

1. Begin by exploring pressures important to your study area. What are big stressors acting along your coastlines?
2. Are data available to measure these stressors? If not, are other indirect measures or proxies available to represent these stressors?
3. Evaluate the pressures included in the global assessment. For example, if there is no mariculture in your study area, you could remove pressures data layers that only affect this goal (i.e. genetic escapes).
4. Are all of them relevant? Are there local data that can be substituted in the place of global data?
5. Determine the pressure category for any additional stressors in your study area, and add it to the pressures matrix.
6. When all stressors are included in the pressures matrix, determine which goals it affects. Then, determine the weight rankings of all stressors for each goal. Use literature and expert judgement to determine this.
7. Prepare each pressure data layer as described in this manual only after steps 1-6 are completed. In addition to the proper formatting for the Toolbox, pressures data must be rescaled (normalized) on a unitless scale from 0 - 1, where 0 is no stressor at all and 1 is the highest possible value for the stressor, or the value at which the goal achievement is completely impaired. You will have to determine how to rescale the data, whether it is based on the highest value in the data range or other methods.

4.6.2.1 Including pressures from global assessments If you are not able to find local data for stressors, you may use the data from the global assessments for your country. For most of the stressors, this means that there will not be differences between the subcountry regions (reporting regions) within your study area. However, several stressors included in the global assessment are based on spatial data at high resolution from previous work by Halpern *et al.* (2008) in *Science:* A global map of human impact on marine ecosystems. These data are available at a resolution of 1 km2 for the entire global ocean, and can be extracted for the regions in your study area. The stressors available at 1km2 resolution are indicated below with ** ** **.

Table of pressures layers and descriptions

layer	name
cc_acid**	Ocean acidification

layer	name
cc_slr**	Sea level rise
cc_sst**	Sea surface temperature (SST) anomalies
cc_uv**	UV radiation
fp_art_hb	High bycatch caused by artisanal fishing
fp_art_lb	Low bycatch caused by artisanal fishing
fp_com_hb	High bycatch caused by commercial fishing
fp_com_lb	Low bycatch caused by commercial fishing
fp_targetharvest	Targeted harvest of cetaceans and sea turtles
hd_intertidal	Coastal population density as a proxy for intertidal habitat destruction
hd_subtidal_hb	High bycatch artisanal fishing practices as a proxy for subtidal hard bottom habitat destruction
hd_subtidal_sb	High bycatch commercial fishing practices as a proxy for subtidal soft bottom habitat destruction
po_chemicals**	Ocean-based chemical pollution
po_chemicals_3nm**	Land-based chemical pollution
po_nutrients**	Ocean nutrient pollution
po_nutrients_3nm**	Coastal nutrient pollution
po_pathogens	Access to improved sanitation as a proxy for pathogen pollution
po_trash	Trash pollution
sp_alien	Alien species
sp_genetic	Introduced species as a proxy for genetic escapes
ss_wgi	Weakness of governance indicated with the WGI

Note that chemical and nutrient pollution have both land-based (within 3 nautical miles) and ocean-based (within the entire 200 nautical mile EEZ) elements. This is because how pollution affects different goals will depend on the spatial scale of the goal's activity. Some goals occur far from shore, and nutrient and chemical pollution should be included for all offshore waters: FIS, MAR, ECO, and SPP. However, some goals are really only relevant nearshore, so nutrient and chemical pollution should only be included close to the shoreline (3nm in the global study): AO, CS, CP, TR, ICO, LSP, HAB.

These distinctions won't always apply for smaller-scale assessments. For example, in the US West Coast study (Halpern *et al.* 2014), we did not distinguish between offshore and 3nm and therefore only used the `po_nutrients` data layer.

4.6.3 Incorporating local resilience measures in your assessment

Finding appropriate resilience measures is difficult. It is often difficult to find regulations and indicators that would directly 'balance' individual stressors, but it is worth the effort to explore what information is available in the local context and how it could be included as resilience measures. As previously mentioned, you may be able to construct your own set of indicators for resilience (particularly social resilience) using proxy data.

1. Begin by exploring how resilience could be measured in your study area. What laws and regulations are in place that could provide resilience to ocean health?
2. Are there locally-developed indices that capture social or ecological resilience? Is there information about how each region in your study area are implementing or enforcing the laws?
3. Evaluate the resilience measures are included in the global assessment. Are all of them relevant? Are there local data that can be substituted in the place of global data? Are there resilience measures that should be excluded entirely?
4. Assign the resilience measure to the appropriate goal. Since resilience measures are in response to pressures that have a weight rank of 2 or 3 effect on a certain goal, determining which goals ecological and social resilience measures effect follows the same pattern as the pressures matrix. For goal-specific resilience measures, assign the resilience measure to the appropriate goal.

5. Prepare each resilience data layer only after steps 1-6 are completed. In addition to the proper formatting for the Toolbox, resilience data must be rescaled (normalized) on a unitless scale from 0 - 1. You will have to determine how to rescale the data, whether it is based on the highest value in the data range or other methods.

4.6.3.1 Including resilience measures from global assessments Because resilience relies heavily upon regulations relevant to ocean health, local measures are far more appropriate than those included in global assessments, which likely do not reflect local management targets.

Table of resilience layers and descriptions

layer	name
alien_species	Alien species
cites	Resilience from commitment to CITES
fishing_v1	CBD survey: coastal fishing v1
fishing_v1_eez	CBD survey: ocean fishing v1
fishing_v2_eez	CBD survey: ocean fishing v2
fishing_v3	CBD survey: coastal fishing v3
fishing_v3_eez	CBD survey: ocean fishing v3
habitat	CBD survey: habitat
habitat_combo	CBD survey: coastal habitat
habitat_combo_eez	CBD survey: ocean habitat
li_gci	GCI: competitiveness in achieving sustained economic prosperity
li_sector_evenness	Sector evenness as a measure of economic diversity
mariculture	CBD survey: mariculture
msi_gov	MSI sustainability and regulations
species_diversity	Ocean ecological integrity
species_diversity_3nm	Coastal ecological integrity
tourism	CBD survey: tourism
water	CBD survey: water
wgi_all	Strength of governance indicated with the WGI

* *CBD = Convention on Biological Diversity; GCI = Global Competitiveness Index; MSI = Mariculture Sustainability Index; WGI = World Governance Indicators.*

5 The Ocean Health Index Toolbox

Section Summary:

In this section, you will learn the basics of how to use OHI tools for conducting an assessment. You will be introduced to the files you will be working with, how to prepare them, and you will learn how concepts such as status, trend, pressures, and resilience are used together to create the final score. You will also learn what to do in cases of missing data.

TIP: Knowing where your data gaps are will make gapfilling easier in this process.

The OHI Toolbox is an ecosystem of data, scripts, and structure required to calculate OHI scores at any scale. Toolbox scripts are open source, written in the software language R, and data inputted into the Toolbox are **comma-separated-value**, or *.csv* files, which can be created or edited using text editors or Microsoft Excel. Files are stored within two folders called **repositories**, or *(repos)*, such that

OHI Toolbox = your assessment repo + `ohi core functions` repo.

We access and interact with the Toolbox ecosystem through an online collaborative platform called **GitHub**. GitHub stores the **R** scripts and *.csv* files in a folder called a repository, which is found online and can also be downloaded on your computer and synced with the online version. GitHub tracks changes by all collaborators working on the project through time, and saves all versions for comparison. The section, "**Installing the Toolbox**," provides instruction on how to download GitHub repositories to your computer, but everything is also available online.

The Toolbox is used to calculate final scores. But, perhaps more importantly, it can also be used to organize an assessment, including data identification and management. The Toolbox can additionally be used to compare how different management scenarios could affect overall ocean health, which can inform effective strategies for ocean resource management at a local scale.

5.1 File System for Assessment Repositories

This section is an orientation to the files within your assessment repository. The file system structure is the same whether you view your assessment repository online or after downloading or cloning to your computer (see section, **"Installing the Toolbox"**).

Throughout this example, we will use Ecuador's assessment repository as a guide. It's available at https://github.com/OHI-Science/ecu.

5.1.1 Assessments and scenarios

Your *assessment repository* contains a *scenario folder*, which by default is named `subcountry2014`. This scenario folder contains all the files needed to calculate scores, and they are described in detail below.

The scenario folder is named `subcountry2014` because it contains data for your country used in the 2014 global assessment. These data in most cases were attributed equally to all regions within your study area (for example, data used for Ecuador in the global assessment was attributed to all coastal states in the files within `subcountry2014`).

You will be able to rename your scenario folder to better reflect the spatial and temporal scale of your scenario after you have set up your GitHub account. We recommend that the name defines the scale of the regions and the year. Eventually, you will likely have multiple scenario folders that contain data for subsequent years or modifications to explore policy alternatives.

In the above figure, `ecu` is the **assessment repository** and `subcountry2014` is the **scenario folder**. Note that files with names preceded by a '.' do not appear when not viewing from github.com; this is because these files are specific to GitHub.

Within the `subcountry2014` folder area all the inputs required by the Toolbox. See **Modifying and Creating Data Layers** for more information on the files you will commonly modify.

5.1.2 *layers.csv*

TIP: Keep `layers.csv` handy. It's a very useful reference throughout the assessment process.

`layers.csv` is the registry that manages all data required for the assessment. All relevant data are prepared as a 'data layer' and registered in this file. The Toolbox will rely on information from this file to use the data layers and display information on the WebApp. You will update some of the layers in `layers.csv`, and some of them will be auto-generated by the Toolbox code when it's running.

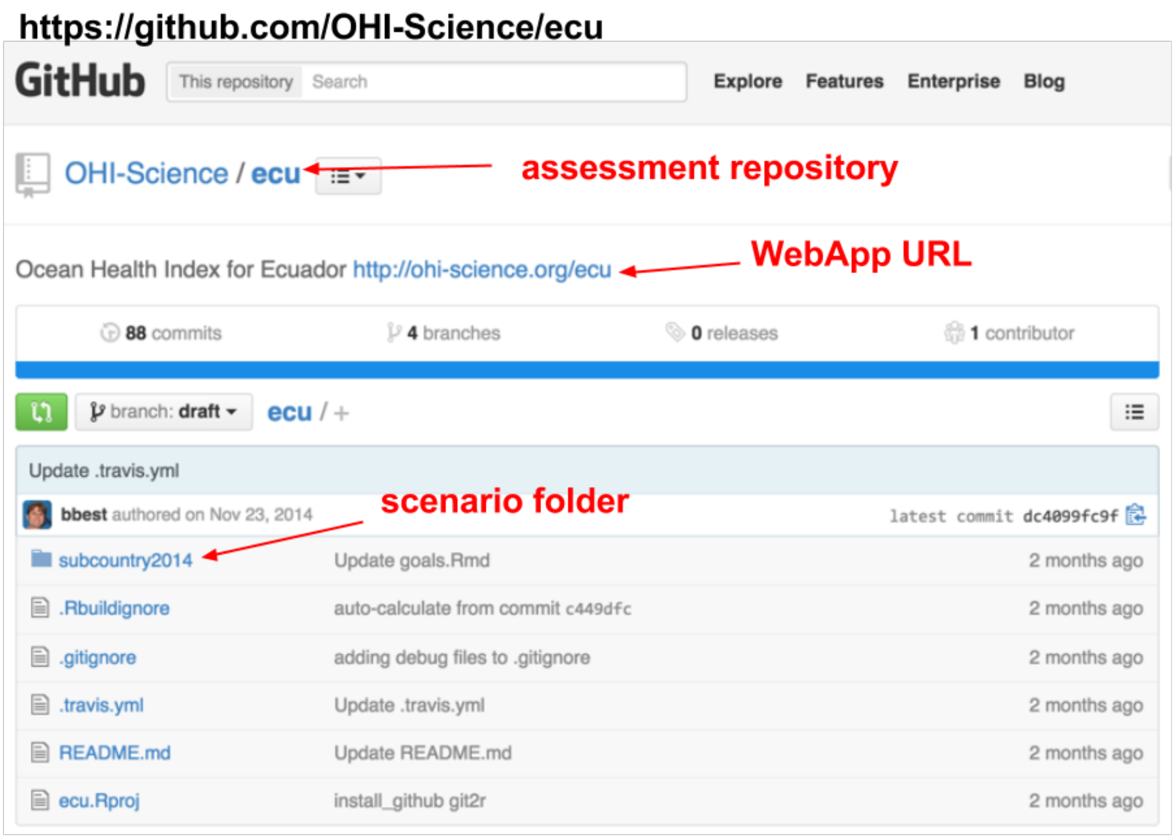

https://github.com/OHI-Science/ecu
GitHub
This repository
Search
Explore
Features
Enterprise
Blog
OHI-Science / ecu
assessment repository
Ocean Health Index for Ecuador http://ohi-science.org/ecu
WebApp URL
88 commits
4 branches
0 releases
1 contributor
branch: draft
ecu / +
Update .travis.yml
bbest authored on Nov 23, 2014
scenario folder
latest commit dc4099fc9f
subcountry2014
Update goals.Rmd
2 months ago
.Rbuildignore
auto-calculate from commit c449dfc
2 months ago
.gitignore
adding debug files to .gitignore
2 months ago
.travis.yml
Update .travis.yml
2 months ago
README.md
Update README.md
2 months ago
ecu.Rproj
install_github git2r
2 months ago

Figure 15:

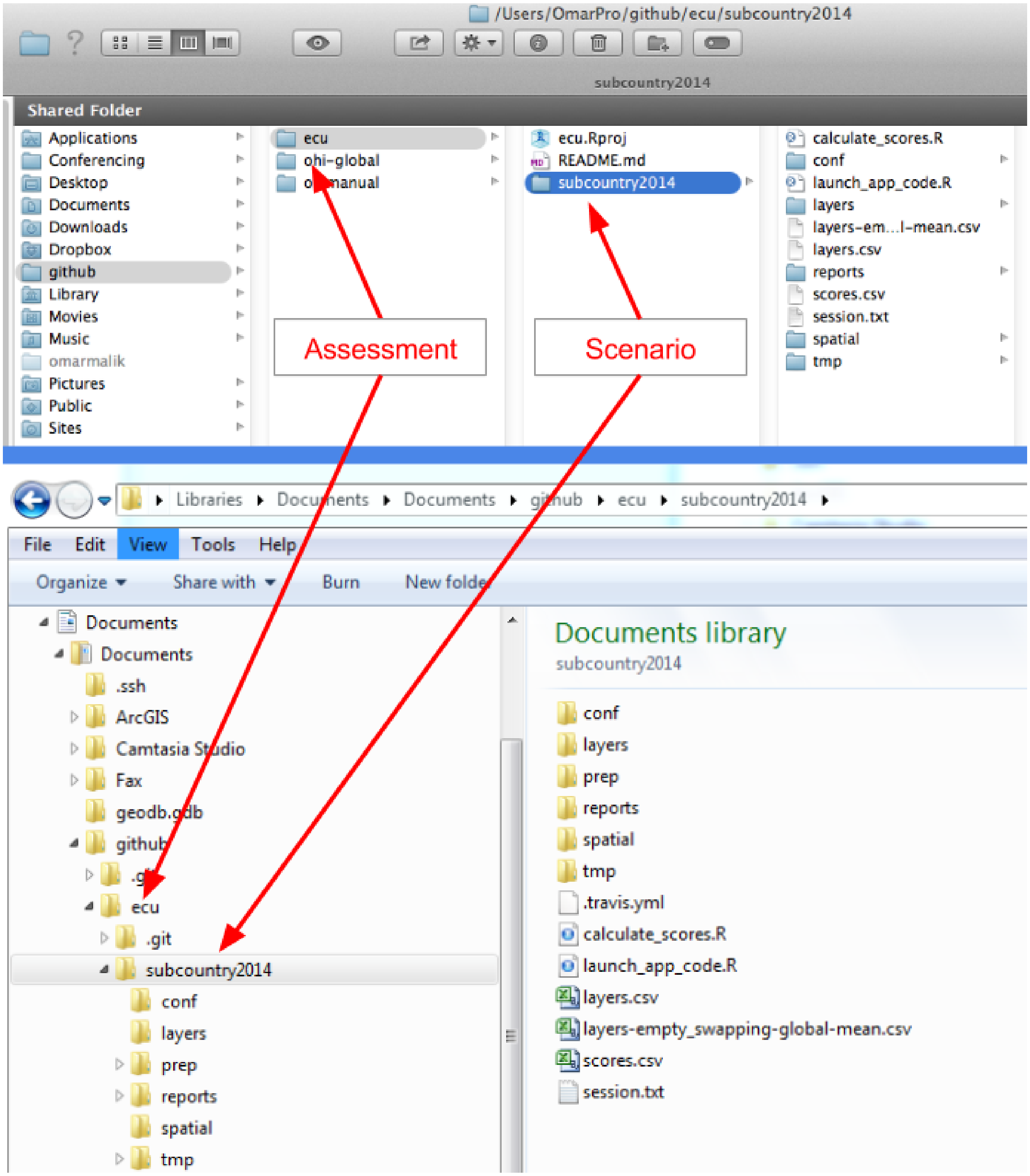


Figure 16: Navigating the assessment repository. The figure shows Mac folder navigation above and Windows navigation below.

	targets	layer	name	description	fld_value	units	filename
1	targets	layer	name	description	fld_value	units	filename
2	AO	ao_access	Fisheries manage	The opportunity fc	value	value	ao_access.csv
3	AO	ao_need	Purchasing powe	The per capita pu	value	value	ao_need.csv
4	CW	cw_coastalpopn_tren	Coastal human p	Coastal populatio	trend	trend score	cw_coastalpopn_tr
5	CW	cw_fertilizer_trend	Fertilizer consum	Statistics on fertili	trend.score	trend score	cw_fertilizer_trend.
6	CW	cw_pathogen_trend	Trends in access	Trends in percent	trend	trend score	cw_pathogen_trend
7	CW	cw_pesticide_trend	Pesticide consum	Statistics on pesti	trend.score	trend score	cw_pesticide_trend
8	FIS	fis_b_bmsy	B/Bmsy estimates obtained using th		b_bmsy	B / B_msy	fis_b_bmsy.csv
9	FIS	fis_meancatch	Catch data for ea	Reported data inc	mean_catch	metric tons	fis_meancatch.csv

Figure 17:

When you open `layers.csv`, you'll see that each row of information represents a specific data layer that has been prepared for the Toolbox. The first columns (*targets, layer, name, description, fld_value, units, filename*) contain information that will be updated by your team as you incorporate your own data and edits; all other columns are generated later by the Toolbox as it confirms data formatting and content. The first columns have the following information:

- **targets** indicates which goal or dimension uses the data layer. Goals are indicated with two-letter codes and sub-goals are indicated with three-letter codes, with pressures, resilience, and spatial layers indicated separately.
- Food Provision (FP): Fisheries (FIS) and Mariculture (MAR)
- Artisanal Fishing Opportunity (AO)
- Natural Products (NP)
- Coastal Protection (CP)
- Carbon Storage (CS)
- Livelihoods and Economies (LE): Livelihoods (LIV) and Economies (ECO)
- Tourism and Recreation (TR)
- Sense of Place: Lasting Special Places (LSP) and Iconic Species (ICO)
- Clean Waters (CW)
- Biodiversity (BD): Habitats (HAB) and Species (SPP)
- **layer** is the identifying name of the data layer, which will be used in R scripts like `functions.R` and *.csv* files like `pressures_matrix.csv` and `resilience_matrix.csv`. This is also displayed on the WebApp under the drop-down menu when the variable type is 'input layer'.
- **name** is a longer title of the data layer; this is displayed on the WebApp under the drop-down menu when the variable type is 'input layer'.
- **description** is further description of the data layer; this is also displayed on the WebApp under the drop-down menu when the variable type is 'input layer'.
- **fld_value** indicates the units along with the units column.
- **units** unit of measure in which the data are reported.
- **filename** is the *.csv* filename that holds the data layer information, and is located in the folder `subcountry2014/layers`.

5.1.3 *layers* folder

The `layers` folder contains every data layer as an individual *.csv* file. The names of the *.csv* files within the layers folder correspond to those listed in the *filename* column of the `layers.csv` file described above. All *.csv* files can be read with text editors or with Microsoft Excel or similar software.

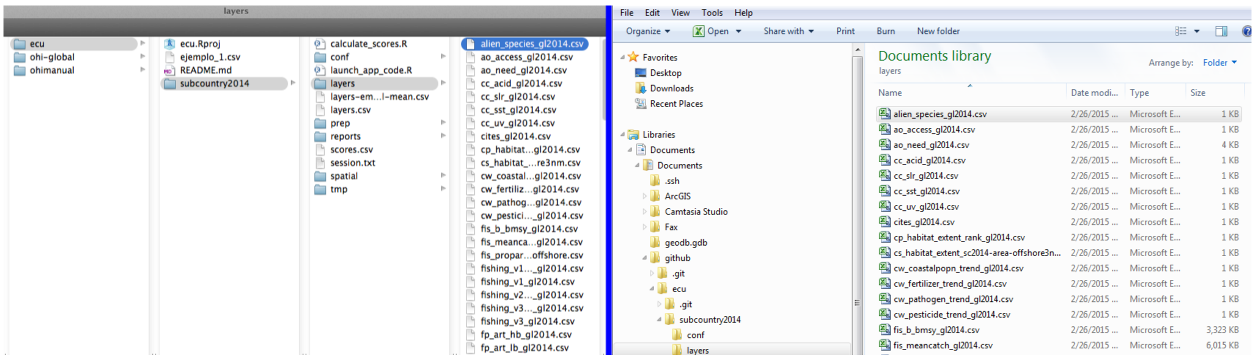


Figure 18: The `layers` folder contains every data layer as an individual *.csv* file. Mac navigation is shown on the left and Windows navigation is shown on the right.

Note that each *.csv* file within the `layers` folder has a specific format that the Toolbox expects and requires. Comma separated value files (*.csv* files) can be opened with text editor software, or will open by default by Microsoft Excel or similar software.

Now, open the `layers/alien_species.csv` file: note the unique region identifier (*rgn_id*) with a single associated *score* or *value*, and that the data are presented in 'long format' with minimal columns. See the section on *Formatting Data for the Toolbox* for further details and instructions. Scores can be viewed through the WebApp using the 'Input Layer' pulldown menu on the App page.

> TIP: You can check your region identifiers (*rgn_id*) in the `rgn_labels.csv` file in the `layers` folder.

5.1.4 *conf* folder

The `conf` (configuration) folder includes R functions (`config.R` and `functions.R`) and *.csv* files containing information that will be accessed by the R functions (`goals.csv`, `pressures_matrix.csv`, `resilience_matrix.csv`, and `resilience_weights.csv`).

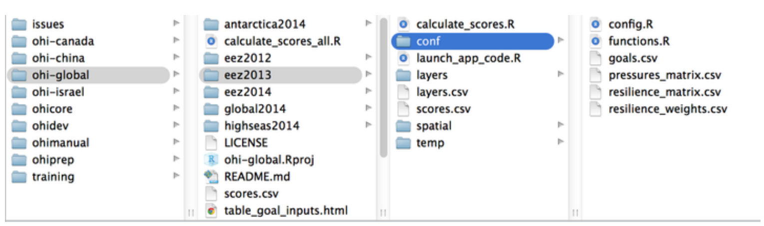


Figure 19: The `conf` folder contains important R functions and *.csv* files. Mac navigation is shown on the left and Windows is shown on the right.

5.1.4.1 *config.R*

`config.R` is an R script that configures labeling and constants appropriately.

5.1.4.2 *functions.R*

`functions.R` contains functions for each goal and sub-goal model, which calculate the status and trend using data layers identified as 'layers' in `layers.csv`. When you modify or develop new goal models, you will modify `functions.R`.

> TIP: It's useful to skip to different sections of `functions.R` to see how key calculations are being done. See section, **Update *Functions.R***.

5.1.4.3 *goals.csv*

`goals.csv` is a list of goals and sub-goals and their weights used to calculate the final score for each goal. Other information includes the goal description that is also presented in the WebApp. `goals.csv` also indicates the arguments passed to `functions.R`. These are indicated by two columns: *preindex_function* (functions for all goals that do not have sub-goals, and functions for all sub-goals) and *postindex_function* (functions for goals with sub-goals).

> TIP: It's important to check the weightings and preindex functions if you're planning to change the goal or sub-goal models.

5.1.4.4 *pressures_matrix.csv*

`pressures_matrix.csv` defines the different types of ocean pressures and the goals they affect.

Each column in the pressures matrix identifies a data layer that is also registered in `layers.csv`: and has a prefix (for example: `po_` for the pollution category). The pressure data layers are also required to have a value for every region in the study area, with the region scores ranging from 0-1.

5.1.4.5 *resilience_matrix.csv*

`resilience_matrix.csv` defines the different types of resilience with the goals that they affect.

Like the pressures matrix, the resilience matrix also has weights depending on the level of protection. However, these weights are in a separate file: `resilience_weights.csv`.

Each column in the resilience matrix is a data layer that is also registered in `layers.csv`. Resilience layers, like the pressure layers, are also required to have a value for every region in the study area. Resilience layers each have a score between 0-1.

5.1.4.6 *resilience_weights.csv*

`resilience_weights.csv` describes the weight of various resilience layers, which in Halpern *et al.* 2012 (*Nature*) were determined based on scientific literature and expert opinion.

5.1.5 *install_ohicore.R*

This script will install `ohicore`, the engine behind all Toolbox calculations. You will only need to run this script only one time.

5.1.6 *launch_app_code.R*

The Toolbox can be launched on your computer so that you can visualize any edits you make while you are offline. To do this, you will run the code in `launch_app_code.R`. Make sure you are in the `subcountry2014` directory at that time: `setwd(~/github/ecu/subcountry2014)`

5.1.7 *calculate_scores.R*

`calculate_scores.R` is a script that tells the Toolbox to calculate scores using the *.csv* files in the `layers` folder that are registered in `layers.csv` and the configurations identified in `config.R`. Scores will be saved in `scores.csv`.

5.1.8 *scores.csv*

`scores.csv` contains the calculated scores for the assessment. Currently, these scores were calculated using data for your country from the global 2014 assessment. Scores are reported for each dimension (future, pressures, resilience, score, status, trend) for each region in the study area (with region identifier), and are presented in 'long' format. Scores can be viewed through the WebApp using the 'Output Score' pulldown menu on the 'App' page.

5.1.9 *spatial* folder

The spatial folder contains a single file, `regions_gcs.js`. This is a spatial file in the JSON format; it spatially identifies the study area and regions for the assessment. If you plan to modify your study area or regions, you will need to upload a *.js* file with appropriate offshore boundaries. You will need a GIS analyst to do this: see http://ohi-science.org/pages/create_regions.html for some instruction.

5.1.10 *layers-empty_swapping-global-mean.csv*

This file contains a list of data layers that were used in the global assessment while not for your country. Without these data for your country, global averages are included in your `subcountry2014` scenario folder so the Toolbox can calculate scores until you replace these data with appropriate data for your study area. This file is not used anywhere by the Toolbox but is a registry of data layers that should prioritized to be replaced with your own local data layers.

5.1.11 Relaunching the Toolbox

After the initial Toolbox setup, further launches of the Toolbox can be done without the software program R. Instead, PC users can double-click the `launchApp.bat` file and Mac users can double-click the `launchApp.command` file.

5.2 Formatting Data for the Toolbox

5.2.1 Introduction

The OHI Toolbox is designed to work in the programming language **R** using input data stored in text-based *.csv* files (*csv* stands for 'comma-separated value'; these files can be opened as a spreadsheet using Microsoft Excel or similar programs). Each data layer (data input) has its own *.csv* file, which is combined with others within the Toolbox for the model calculations. These data layers are used for calculating goal scores, meaning that they are inputs for status, trend, pressures, and resilience. The global analysis included over 100 data layer files, and there will probably be as many in your own assessments. This section describes and provides examples of how to format the data layers for the Toolbox.

OHI goal scores are calculated at the scale of the reporting unit, which is called a '**region**' and then combined using an area-weighted average to produce the score for the overall area assessed, called a '**study area**'. The OHI Toolbox expects each data file to be in a specific format, with data available for every region within the study area, with data layers organized in 'long' format (as few columns as possible), and with a unique region identifier (*rgn_id*) associated with a single *score* or *value*. In order to calculate trend, input data must be available as a time series for at least 5 recent years (and the longer the time series the better, as this can be used in setting temporal reference points).

The example below shows information for a study area with 4 regions. There are two different (and separate) data layer files: tourism count (`tr_total.csv`) and natural products harvested, in metric tonnes (`np_harvest_tonnes.csv`). Each file has data for four regions (1-4) in different years, and the second has an additional 'categories' column for the different types of natural products that were harvested. In this example, the two data layers are appropriate for status calculations with the Toolbox because:

1. At least five years of data are available,
2. There are no data gaps
3. Data are presented in 'long' or 'narrow' format (not 'wide' format – see "**Long Formatting**"" section).

Example of data in the appropriate format:

rgn_id	year	count
1	2005	177.14
1	2006	201.39
1	2007	199.81
1	2008	212.99
1	2009	228.81
2	2005	580.98
2	2006	730.18
2	2007	717.00
2	2008	851.44
2	2009	836.68
3	2005	129.69
3	2006	173.45
3	2007	229.86
3	2008	231.44
3	2009	221.95
4	2005	397.00
4	2006	566.00
4	2007	591.00
4	2008	1154.00
4	2009	1570.00

rgn_id	product	year	tonnes
1	ornamentals	2005	10327
1	ornamentals	2006	10389
1	ornamentals	2007	10897
1	ornamentals	2008	9985
1	ornamentals	2009	9001
2	shells	2005	6179
2	shells	2006	6823
2	shells	2007	8239
2	shells	2008	8819
2	shells	2009	9205
3	coral	2005	22079
3	coral	2006	25297
3	coral	2007	25361
3	coral	2008	23817
3	coral	2009	23623
4	shells	2005	7500
4	shells	2006	9700
4	shells	2007	8600
4	shells	2008	9400
4	shells	2009	9300

Figure 20:

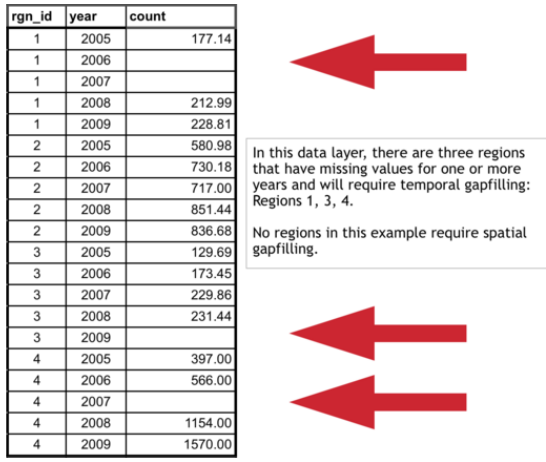
5.2.2 Gapfilling

It is important that data prepared for the Toolbox have no missing values or 'gaps'. Data gaps can occur in two main ways: 1) **temporal gaps**: when several years in a time series in a single region have missing data, and 2) **spatial gaps**: when all years for a region have missing data (and therefore the whole region is 'missing' for that data layer).

How these gaps are filled will depend on the data and regions themselves, and requires thoughtful, logical decisions to most reasonably fill gaps. Each data layer can be gapfilled using different approaches. Some data layers will require both temporal and spatial gapfilling. The examples below highlight some example of temporal and spatial gapfilling.

All decisions of gapfilling should be documented to ensure transparency and reproducibility. The examples below are in Excel, but programming these changes in software like R is preferred because it promotes easy transparency and reproducibility.

5.2.2.1 Temporal gapfilling Temporal gaps occur when a region is missing data for some years. The Toolbox requires data for each year for every region. It is important to make an informed decision about how to temporally gapfill data.



rgn_id	year	count
1	2005	177.14
1	2006	
1	2007	
1	2008	212.99
1	2009	228.81
2	2005	580.98
2	2006	730.18
2	2007	717.00
2	2008	851.44
2	2009	836.68
3	2005	129.69
3	2006	173.45
3	2007	229.86
3	2008	231.44
3	2009	
4	2005	397.00
4	2006	566.00
4	2007	
4	2008	1154.00
4	2009	1570.00

Figure 21:

Often, regression models are the best way to estimate data and fill temporal gaps. Here we give an example that assumes a linear relationship between the year and value variables within a region. If data do not fit a linear framework, other models may be fit to help with gapfilling. Here we give an example assuming linearity.

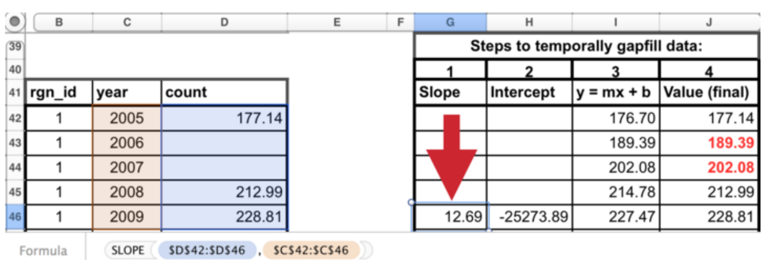
Using a linear model can be done in most programming languages using specific functions, but here we show this step-by-step using functions in Excel for Region 1.

Temporal gapfilling example (assumes linearity: able to be represented by a straight line on a graph)):

There are four steps to temporally gapfill with a linear model, illustrated in the figures with four columns.

1. Calculate the slope for each region

The first step is to calculate the slope of the line that is fitted through the available data points. This can be done in Excel using the **SLOPE(known_y's,known_x's)** function as highlighted in the figure below. In this case, the x-axis is *years* (2005, 2006, etc…), the y-axis is *count*, and the Excel function automatically plots and fits a line through the known values (177.14 in 2005, 212.99 in 2008, and 228.81 in 2009), and subsequently calculates the slope (12.69).



rgn_id	year	count	Slope (1)	Intercept (2)	y = mx + b (3)	Value (final) (4)
1	2005	177.14			176.70	177.14
1	2006				189.39	189.39
1	2007				202.08	202.08
1	2008	212.99			214.78	212.99
1	2009	228.81	12.69	-25273.89	227.47	228.81

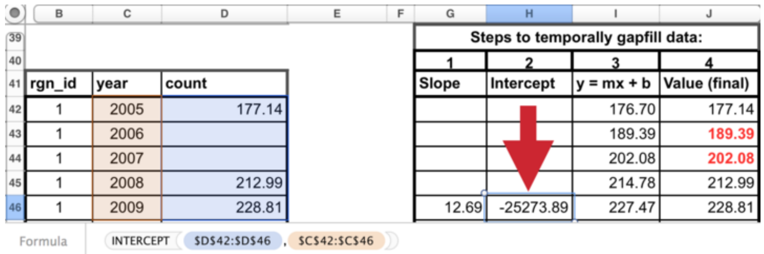
Figure 22:

2. Calculate the y-intercept for each region

The next step is to calculate the intercept of the line that is fitted through the available data points. This can be done in Excel similarly as for the slope calculation, using the the **INTERCEPT(known_y's,known_x's)** function that calculates the y-intercept (-25273.89) of the fitted line.

3. Calculate y for all years

The slope and y-intercept that were calculated in steps 1 and 2 can then be used along with the year (independent variable) to calculate the unknown 'y-values'. To do so, simply replace the known three values



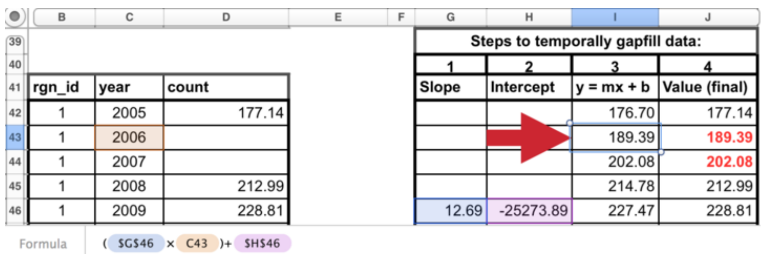
rgn_id	year	count
1	2005	177.14
1	2006	
1	2007	
1	2008	212.99
1	2009	228.81

Steps to temporally gapfill data:			
1	2	3	4
Slope	Intercept	y = mx + b	Value (final)
		176.70	177.14
		189.39	189.39
		202.08	202.08
		214.78	212.99
12.69	-25273.89	227.47	228.81

Formula INTERCEPT($D$42:$D$46, $C$42:$C$46)

Figure 23:

into the **y = mx + b** equation (m=slope, x=year, b=intercept), to calculate the unknown 'count' for a given year (189.39 in 2006, and 202.08 in 2007).



rgn_id	year	count
1	2005	177.14
1	2006	
1	2007	
1	2008	212.99
1	2009	228.81

Steps to temporally gapfill data:			
1	2	3	4
Slope	Intercept	y = mx + b	Value (final)
		176.70	177.14
		189.39	189.39
		202.08	202.08
		214.78	212.99
12.69	-25273.89	227.47	228.81

Formula ($G$46 × C43)+ $H$46

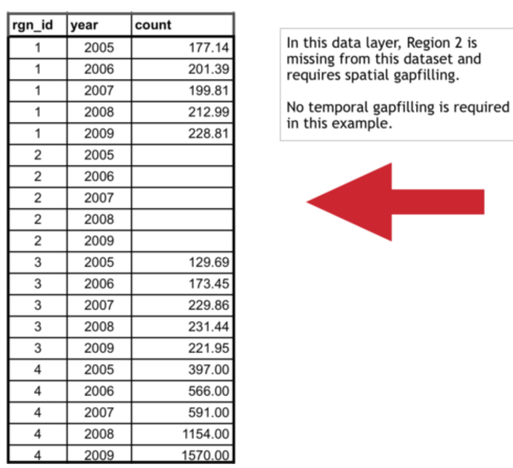
Figure 24:

4. Replace modeled values into original data where gaps had occurred

Substitute these modeled values that were previously gaps in the timeseriew. *The data layer is now ready for the Toolbox, gapfilled and in the appropriate format.*

5.2.2.2 Spatial gapfilling

Spatial gaps are when no data are available for a particular region. The Toolbox requires data for each region. It is important to make an informed decision about how to spatially gapfilling data.



rgn_id	year	count
1	2005	177.14
1	2006	201.39
1	2007	199.81
1	2008	212.99
1	2009	228.81
2	2005	
2	2006	
2	2007	
2	2008	
2	2009	
3	2005	129.69
3	2006	173.45
3	2007	229.86
3	2008	231.44
3	2009	221.95
4	2005	397.00
4	2006	566.00
4	2007	591.00
4	2008	1154.00
4	2009	1570.00

Figure 25:

To fill gaps spatially, you must assume that one region is like another, and data from another region is adequate to be substituted in place of the missing data. This will depend on the type of data and the properties of the regions requiring gapfilling. For example, if a region is missing data but has similar properties to a different region that does have data, the missing data could be 'borrowed' from the region with information. Each data layer can be gapfilled using a different approach when necessary.

Characteristics of regions requiring gapfilling that can help determine which type of spatial gapfilling to use:

1. proximity: can it be assumed that nearby regions have similar properties?
2. study area: are data reported for the study area, and can those data be used for subcountry regions?
3. demographic information: can it be assumed a region with a similar population size has similar data?

Spatial gapfilling example:

For a certain data layer, suppose the second region (*rgn_id 2*) has no data reported, as illustrated in the figure above. How to spatially gapfill *rgn_id 2* requires thinking about the properties and characteristics of the region and the data, in this case, tourist count.

Here are properties that can be important for decision making:

rgn_id 2:

- is located between *rgn_id 1* and 3
- is larger than *rgn_id 1*
- has similar population size/demographics to *rgn_id 3*
- has not been growing as quickly as *rgn_id 4*

There is no absolute answer of how to best gapfill *rgn_id 2*. Here are a few reasonable possibilities:

Assign *rgn_id 2* values from:

- *rgn_id 1* because it is in close proximity to *rgn_id 2*
- *rgn_id 3* because it is in close proximity to *rgn_id 2* and has similar population size/demographics
- *rgn_id 1* and 3 averaged since they are in close proximity to *rgn_id 2*

Suppose the decision was made to gapfill *rgn_id 2* using the mean of *rgn_id 1* and *3* since this would use a combination of both of those regions. Again, other possibilities could be equally correct. But some form of spatial gapfilling is required so a decision must be made. The image below illustrates this in Excel.

The data layer is now ready for the Toolbox, gapfilled and in the appropriate format.

5.2.3 Long formatting

The Toolbox expects data to be in 'long' or 'narrow' format. Below are examples of correct and incorrect formatting, and tips on how to transform data into the appropriate format.

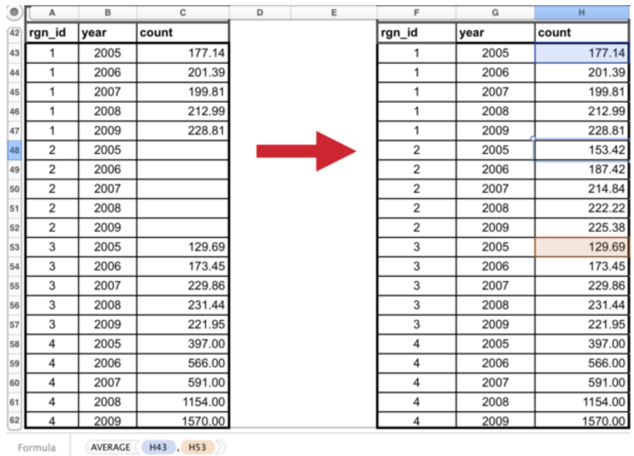
Example of data in an incorrect format:

With 'wide' format, data layers are more difficult to combine with others and more difficult to read and to analyze.

Transforming data into 'narrow' format:

Data are easily transformed in a programming language such as R.

In R, the `reshape` package has the `melt` command, which will melt the data from a wide format into a narrow format. It also can `cast` the data back into a wide format if desired. R documentation:



rgn_id	year	count
1	2005	177.14
1	2006	201.39
1	2007	199.81
1	2008	212.99
1	2009	228.81
2	2005	
2	2006	
2	2007	
2	2008	
2	2009	
3	2005	129.69
3	2006	173.45
3	2007	229.86
3	2008	231.44
3	2009	221.95
4	2005	397.00
4	2006	566.00
4	2007	591.00
4	2008	1154.00
4	2009	1570.00

rgn_id	year	count
1	2005	177.14
1	2006	201.39
1	2007	199.81
1	2008	212.99
1	2009	228.81
2	2005	153.42
2	2006	187.42
2	2007	214.84
2	2008	222.22
2	2009	225.38
3	2005	129.69
3	2006	173.45
3	2007	229.86
3	2008	231.44
3	2009	221.95
4	2005	397.00
4	2006	566.00
4	2007	591.00
4	2008	1154.00
4	2009	1570.00

Figure 26:

		Year									
Region	**DataLayer**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
A	GDP_USDx1000	8	7	30	26	69	39	108	92	261	151
B	GDP_USDx1000	13	9	13	14	10	12	14	10	6	5
C	GDP_USDx1000	2132	2325	2963	3214	2942	2910	1759	2029	2077	2453
D	GDP_USDx1000	21	5	14	2	11	3	26	14	15	100
A	governance_indicator						0.8545	0.5400	0.7062	1	1
B	governance_indicator						0.8564	0.7794	0.8615	1	1
C	governance_indicator						0.8779	1	1	0.8986	1
D	governance_indicator						0.8537	0.5373	0.7044	1	1

Figure 27:

- http://cran.r-project.org/web/packages/reshape2/reshape2.pdf
- http://www.slideshare.net/jeffreybreen/reshaping-data-in-r
- http://tgmstat.wordpress.com/2013/10/31/reshape-and-aggregate-data-with-the-r-package-reshape2/

Example code using the *melt* command in the *reshape2* library. Assume the data above is in a variable called *data_wide*:

```
install.packages('reshape2')
library(reshape2)
data_melt = melt(data=data_wide, id.vars=c('Region', 'DataLayer'), variable.name='Year')
data_melt = data_melt[order(data_melt$DataLayer, data_melt$Region),]
```

Figure 28:

This will melt everything except any identified columns (*Region* and *DataLayer*), and put all other column headers into a new column named *Year*. Data values will then be found in a new column called *value*.

The final step is optional: ordering the data will make it easier for humans to read (R and the Toolbox can read these data without this final step):

Example of data in the appropriate (long) format:

6 Installing the Toolbox

Section Summary:

GDP_USDx1000.csv		
Region	Year	value
A	2000	8
A	2001	7
A	2002	30
A	2003	26
A	2004	69
A	2005	39
A	2006	108
A	2007	92
A	2008	261
A	2009	151
B	2000	13
B	2001	9
B	2002	13
B	2003	14
B	2004	10
B	2005	12
B	2006	14
B	2007	10
B	2008	6
B	2009	5

governance_indicator.csv		
Region	Year	value
A	2000	
A	2001	
A	2002	
A	2003	
A	2004	
A	2005	0.854599407
A	2006	0.540059347
A	2007	0.706231454
A	2008	1
A	2009	1
B	2000	
B	2001	
B	2002	
B	2003	
B	2004	
B	2005	0.856410256
B	2006	0.779487179
B	2007	0.861538462
B	2008	1
B	2009	1

Figure 29:

In this section, you will learn how to successfully download, install, and use the software required to conduct an assessment. You will create a GitHub account and install R, RStudio, git, and the Github desktop app. OHI assessments are conducted through open-source platforms that allow you to make real-time changes with collaborators, and to track progress so that errors can be corrected and new insights can be shared in the future.

6.1 Overview

The **OHI Toolbox** is essentially several folders containing all the files required for an OHI assessment. These folders are stored online on www.github.com, and are called **GitHub repositories**. At this point, you should already be familiar with your assessment's repository, and all of the files it contains (if not, read the section, "**File System for Assessment Repositories**").

Conducting an OHI assessment using GitHub enables collaboration and transparency, and will provide access to the latest developments in the Toolbox software, allowing the OHI team to provide support remotely if necessary.

This section explains the GitHub workflow and how to access and setup required software. Then, it explains how to after modifying files on your own computer, you can use GitHub to upload any modifications you make so that you can work collaboratively with your team.

Required software:

1. **Github App**
2. ** *git* **
3. **R**
4. **RStudio**

6.2 GitHub

GitHub is an open-source development platform that enables easy collaboration and versioning, which means that all saved versions are archived and attributed to each user. It is possible to revert back to any previous version, which is incredibly useful to not only to document what work has been done, but how it differs from work done in the past, and who is responsible for the changes.

Figure 30:

GitHub Vocabulary:

- **clone** ~ download to your computer from online version with synching capabilities enabled
- **commit** ~ message associated with your changes at a point in time
- **pull** ~ sync a repo on your computer with online version
- **push** ~ sync the online repo with your version, only possible after committing

sync = pull + commit + push

6.2.1 Learning GitHub

The following section describes how to use GitHub to access and sync your assessment repository. There are also many great resources available online with more in-depth information:

- **Git and GitHub** by Hadley Wickham: http://r-pkgs.had.co.nz/git.html
- **Collaboration and Time Travel: Version Control with Git, GitHub and RStudio** video tutorial by Hadley Wickham: www.rstudio.com/resources/webinars
- **Good Resources for Learning Git and GitHub** by GitHub: https://help.github.com/articles/good-resources-for-learning-git-and-github/

6.3 Accessing GitHub Repositories

GitHub has an online interface and a desktop application for the version-control software called ** *git.* ** In addition to cloning your GitHub repository to your computer, you will need to download and install *git* software and the GitHub App (application), both of which are freely available.

6.3.1 Create a GitHub account

Create a GitHub account at http://github.com. Choose a username and password. You will use this username and password when you install and set up *git* on your computer.

6.3.2 Install *git* software

How you install *git* will depend on whether you are working on a Windows or Mac computer. It will also depend on your operating system version. If you have problems following these instructions, it is likely because your operating system requires a previous version of *git*. Previous versions are available from http://www.wandisco.com/git/download (you will need to provide your email address).

For Windows:

- Download *git* at http://git-scm.com/downloads and follow the install instructions.
- When running the Windows installer, use all default options except "Adjusting your PATH environment": instead, select "***Run Git from the Windows Command Prompt***". This will allow later compatibility with RStudio.

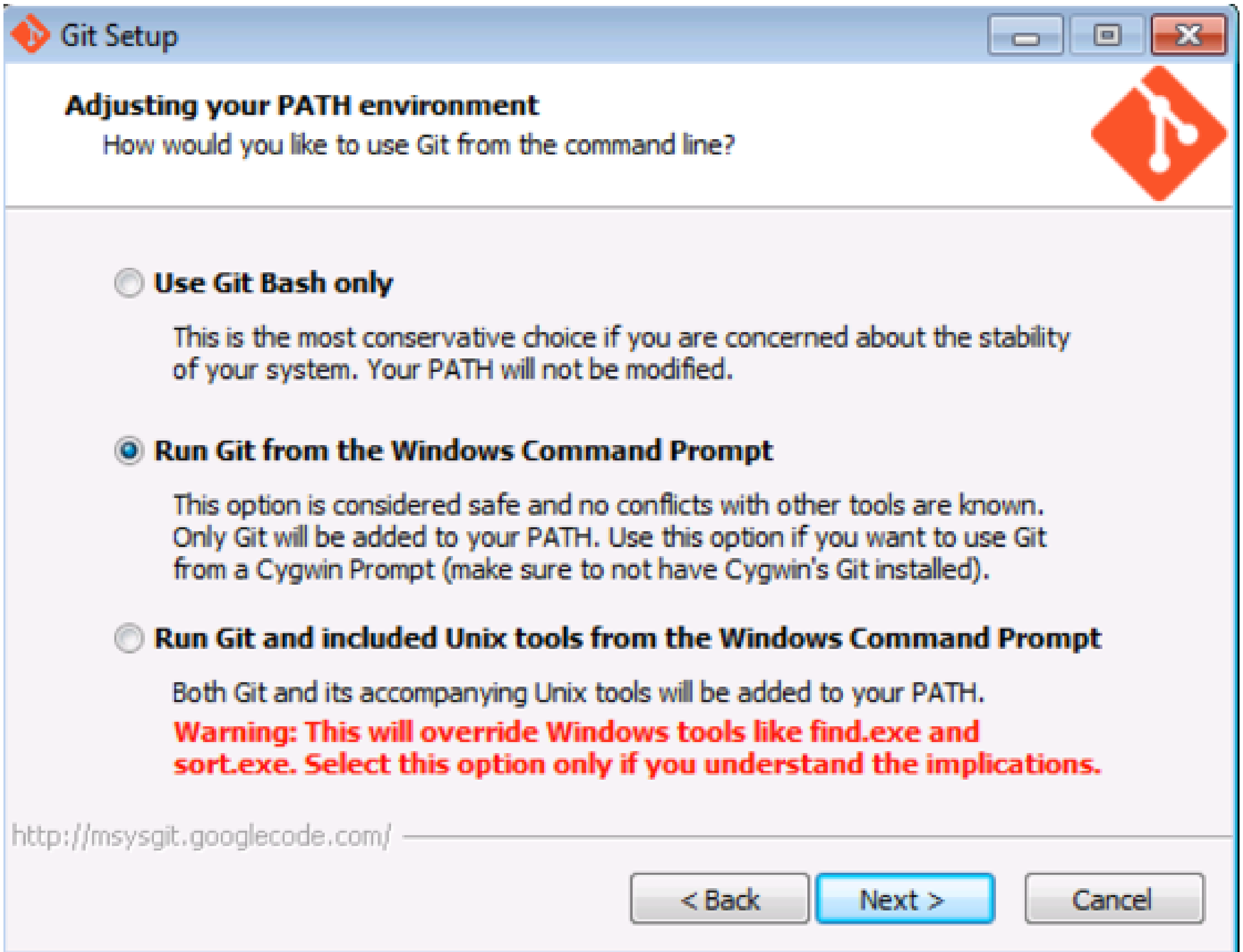


Figure 31:

For Mac:

- Download *git* at http://git-scm.com/downloads and follow the install instructions.
- Apple's Xcode has a command line tools option during install which can override the preferred *git* command line tools. To ensure you are using the latest preferred version of *git*, you will need to launch Terminal and type the following few lines of code:
- Access Terminal from the Applications folder: **Applications** > **Utilities** > **Terminal**. When you launch Terminal a window will appear with your computer's name followed by a `$`. When you type, your commands will appear after the `$`.

Add access your 'bash profile' by typing:

```
pico ~/.bash_profile
```

You are now able to edit your 'bash profile'. Type:

```
export PATH=/usr/local/git/bin:$PATH
```

Exit pico by typing:

> control-X
> y
> return/enter

Exit Terminal by typing:

```
exit
```

Finally, quit Terminal.

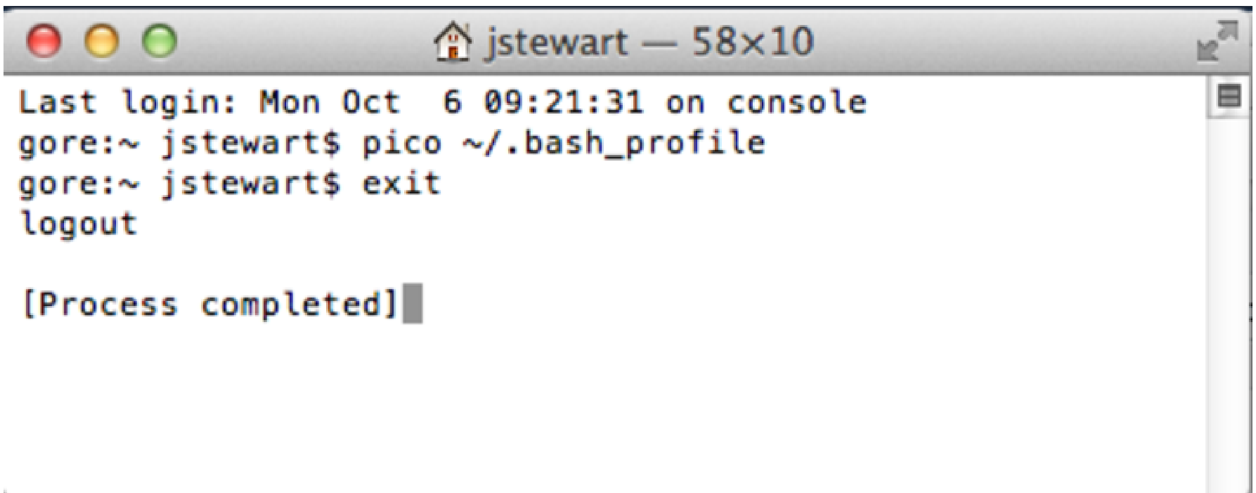


Figure 32:

6.3.3 Set up your Git Identity

After downloading and installing *git*, you will need to set up your **Git Identity**, which identifies you with your work. *Note*: if you have any problems with the following instructions, it is likely because of incompatibility between the version of your operating system and the version of git you downloaded in the previous section. In this case, find and download a compatible version at www.wandisco.com/git/download and then follow the instructions below.

You will set up your GitHub identity using the command line specific to Windows or Mac:

- **Windows**: Start > Run > cmd
- **Mac**: Applications > Utilities > Terminal

In the window, you will see a cursor where you are able to type. Type the following and press return (or enter) at each step. Make sure all spaces and symbols are identical to the example below, including all spaces ( ) and dashes (-).

Substitute your GitHub username instead of jdoe:

```
git config --global user.name jdoe
```

and then: substitute the email address you used to create your GitHub account:

```
git config --global user.email johndoe@example.com
```

You can check settings with the following:

```
git config --list
```

Quit the Terminal after typing:

```
exit
```

6.3.4 Install the GitHub application

There are several options to clone your repository to your local machine. When getting started, we recommend using the GitHub application. This is freely available for download. Follow the default instructions for downloading and installing from the following:

- **Windows**: https://windows.github.com/.
- **Mac**: https://mac.github.com/.

6.3.5 Create a folder called *github* on your computer

Because you will use GitHub to collaborate with your team or request support from the OHI team, it is important you save files in places where the file path that is universal and not specific to your computer. When team members save files in different places, this will create a lot of problems when collaborating, particularly between Macs and Windows machines.

Please create a folder called github in your root directory. The file path for this folder will be:

- **Windows**: `Users\[User]\Documents\github\`
- **Mac**: `Users/[User]/github/`

This folder can be identified by any computer as `~/github/`.

> TIP: You can check the location of your `github` folder by right-clicking the folder icon and selecting 'Get Info' on a Mac or 'Properties' on Windows.

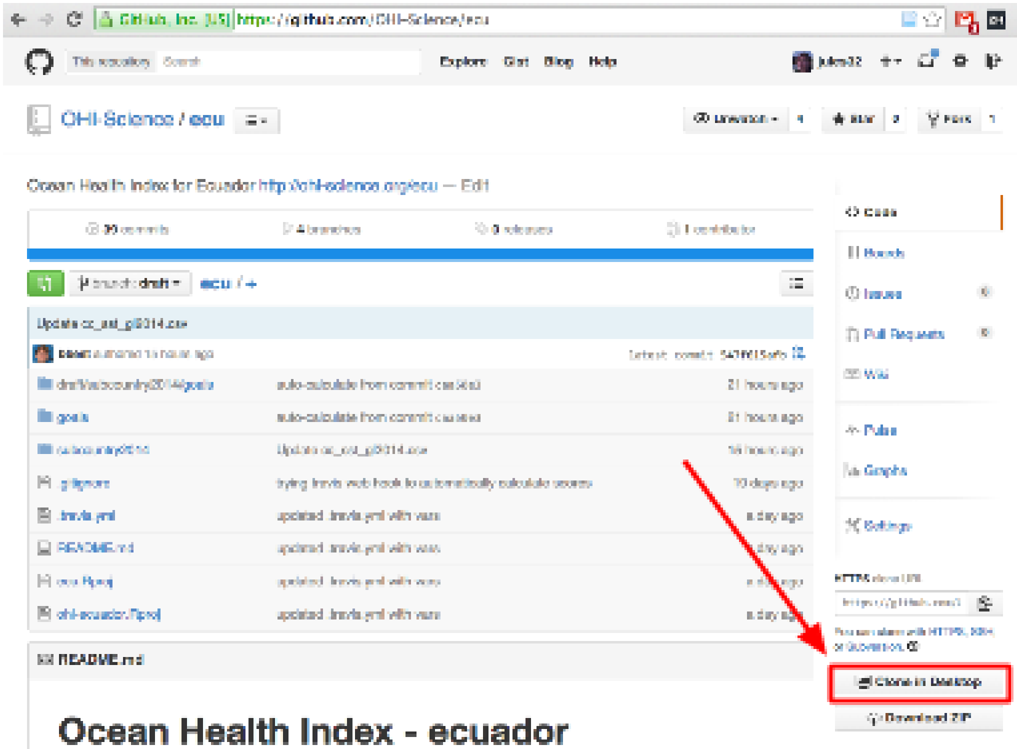


Figure 33:

6.3.6 Clone your repository to your computer

Clone a repository by clicking the 'Clone in Desktop' button on your online repository's homepage (https://github.com/OHI-Science/{[}assessment{]}):

You will be asked where to save this repository: save it into the `github` folder you created. The file path for your assessment will therefore be:

- Windows: C: `\Users\[User]\Documents\github\[assessment] (example: C:\Users\johndoe\Documents\github`
- on a Mac: `/Users/[User]/github/[assessment] (example: /Users/johndoe/github/ecu)`

The assessment can be identified by any computer as `~/github/[assessment]`.

The entire folder will now be saved on your computer.

6.3.7 Update permissions

You need to **email your username to ohi-science@nceas.ucsb.edu** for permission to upload modifications to your GitHub repository (you only need to do this once). Only team members who will be modifying files will need to do this; all other members can view online and download the repository without these permissions.

6.3.8 Work locally

You will then work locally on your own computer, modifying the files in the repository to reflect the desired modifications your team has identified for your assessment. Multiple users can work on the same repository at the same time, so there are steps involved to 'check in' your modifications so they can merge with the work of others without problems. GitHub has specific words for each of these steps. You have already successfully **cloned** an online repository to your local machine. After making modifications, you will **commit** these changes with a description before being able to sync back to the online repository. **Synching** involves both **pulling** any updates from the online repository before **pushing** committed changes back to the server.

> TIP: While you can edit files in the online GitHub repository, we do not recommend this. It is good practice to track changes through commits and syncing.

The example below illustrates GitHub's collaborative workflow with the `ohi-israel` repo owned by `OHI-Science`:

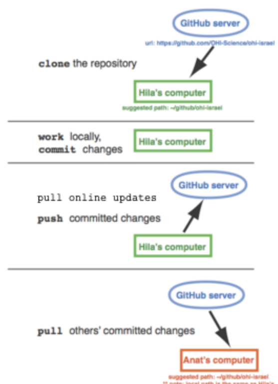


Figure 34:

All changes within your local repository will be tracked by GitHub regardless of the software you use to make the changes. This means that you can delete or paste files in the Mac Finder or Windows Explorer and edit *.csv* files in Excel or a text editor, and still sync these changes with the online repository. We recommend doing as much data manipulation as possible in a programming language like R, to maximize transparency and reproducibility. When modifying R scripts such as `functions.R`, you will need to work in R.

We recommend syncing with either the GitHub App or with RStudio. Both methods require you to commit your changes, before pulling any updates and pushing your modifications. The GitHub App combines the pulling and pushing into one step, called syncing. The following sections show you how to synchronize the repository on your computer with the repository online.

6.3.9 Syncing

When you work on your computer, any edits you make to any files in your repo, using any program, will be tracked by *git*. You can use any of the above to commit and sync your changes back to GitHub. There are many options you can use to sync your edits on a repo with the online version.

- **GitHub App** for Mac and for Windows
- **RStudio**
- **Command line**

If you are just modifying data *.csv* files, you probably only need to use the GitHub App. RStudio is convenient if you are working with *.R* files. Also, the command line can be used by those interested, and there are resources available online.

> TIP: Once you sync your repository, the updated information will be automatically available to the WebApps.

6.3.10 Using the GitHub App to synchronize your repository

The GitHub App will track your modifications and can be used to commit and sync any changes made locally to your repository. Once you are done working on the pertinent files and wish to commit and sync the changes to the online server on the Github server, open the GitHub App. The following example is with the `ecu` repository:

1. Make sure you select the correct repository, located on the left column of the GitHub App window (Step 1 in the figure).
2. Select the different files to which changes have been made (2a), and preview those changes on the right column of the GitHub App window (2b).
3. Once all the changes have been reviewed, write a summary/description in the respective message bars in the GitHub App window (3), then click on 'Commit' (3a) and then 'Sync' (3b) located on the top-right corner of the GitHub App window (Note: If a `Commit` button appears instead of `Commit & Sync`, you can either click `Commit` and then click the `Sync` in this way, or you can alternatively select *Edit > Automatically Sync After Committing* which will then allow you to click on 'Commit and Sync')

Go online and check that your changes are now visible on GitHub online.

6.3.11 Working with R and RStudio

RStudio is a program that can be used to synchronize any modifications you make to files in your assessment's repository, and if you are working in R, it is convenient since you do not need to open the GitHub App. If you do not already have this installed, install the latest version of R and RStudio (and if you do have these installed, check for updates: there are frequent updates to the R software, and the current version is identified on the website). Both R and RStudio are freely available to download.

R: Download the current version of R appropriate for your operating system at http://cran.r-project.org/ and follow the instructions to install it on your computer. If updating, compare the available version on their website with what you already have on your computer by typing sessionInfo() into your R console.

RStudio: Download the current version of RStudio software at www.rstudio.com. RStudio is not updated as often as R, but it is good to check for updates regularly. Note that in this case, you should follow the default install instructions.

If you are working on a Mac, you will need to tell RStudio to use the proper version of Git by doing the updating the preferences for 'Git executable':

RStudio > Preferences… > Git/SVN > Git executable: /usr/local/git/bin/git

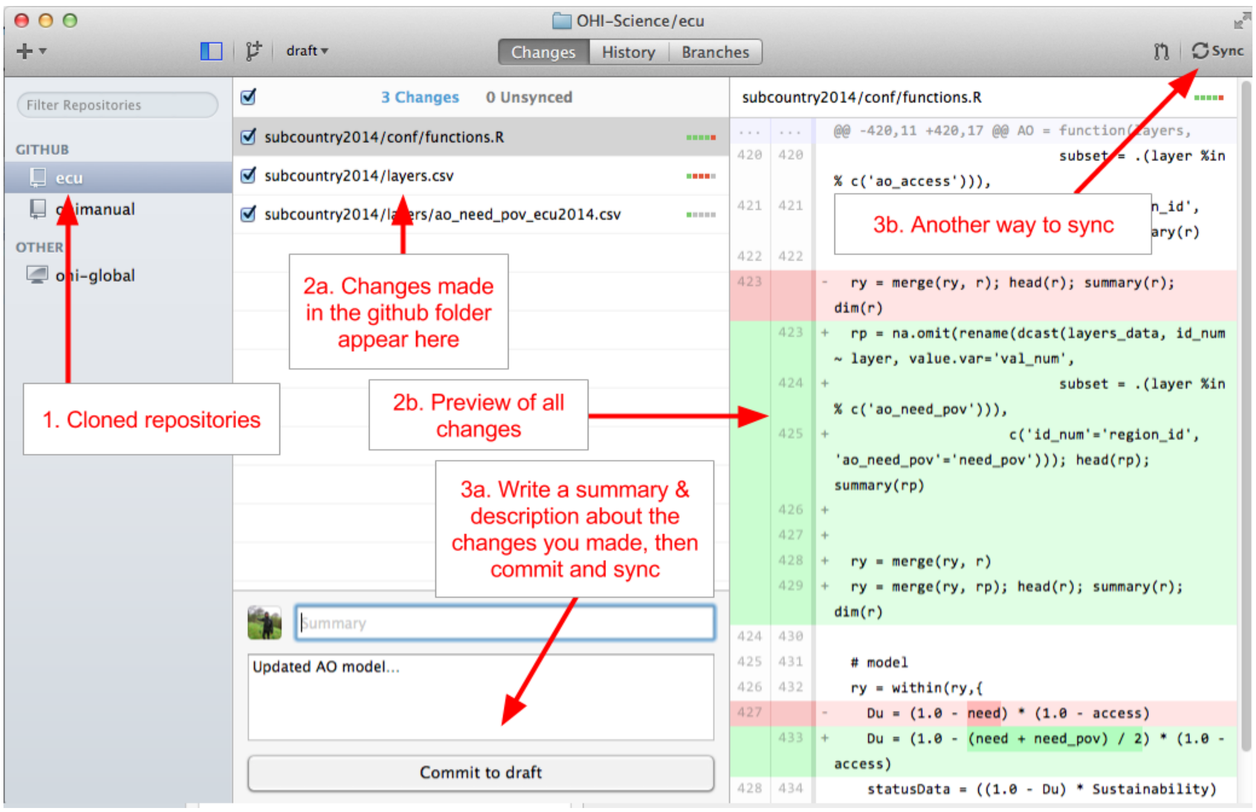


Figure 35: Figure showing the layout of the GitHub App when syncing. Click on 'Commit' and then 'Sync' to push changes to your repository.

6.3.12 Using RStudio to synchronize your repository

RStudio can sync files with GitHub directly, and can be used instead of the GitHub App. Like the GitHub App, it will capture the changes made to any files within the repository, no matter which software was used to modify them. The advantage for using RStudio to sync instead of the GitHub App is if you are working with R scripts already. In RStudio, you sync by first pulling and then pushing (separately); in the GitHub App these two functions are done together.

Launch your project in RStudio by double-clicking the `.Rproj` file in the assessment folder on your local hard drive.

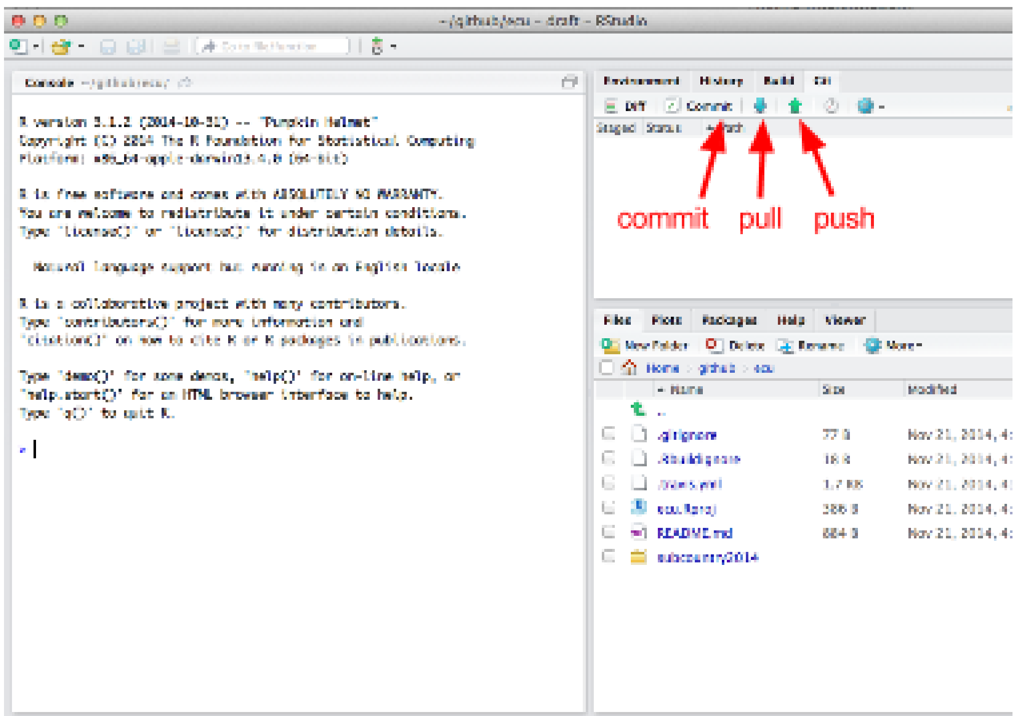


Figure 36:

When you modify or add a file, the file will appear in the 'Git' window once it has been saved. In the example below, the file `test.R` was created.

1. Clicking the 'Staged' box and the 'Commit' button opens a new window where you can review changes.
2. Type a commit message that is informative to the changes you've made.

- Note 1: there will often be multiple files 'staged' at the same time, and so the same commit message will be associated with all of the updated files. It is best to commit changes often with informative commit messages.
- Note 2: clicking on a staged file will identify additions and deletions within that file for your review

3. Click 'Commit' to commit the changes and the commit message

4. Pull any changes that have been made to the online repository. This is important to ensure there are no conflicts with updating the online repository.
5. Push your committed changes to the online repository. Your changes are now visible online.

TIP: If you aren't seeing your changes in the 'Git' window, try saving the file again.

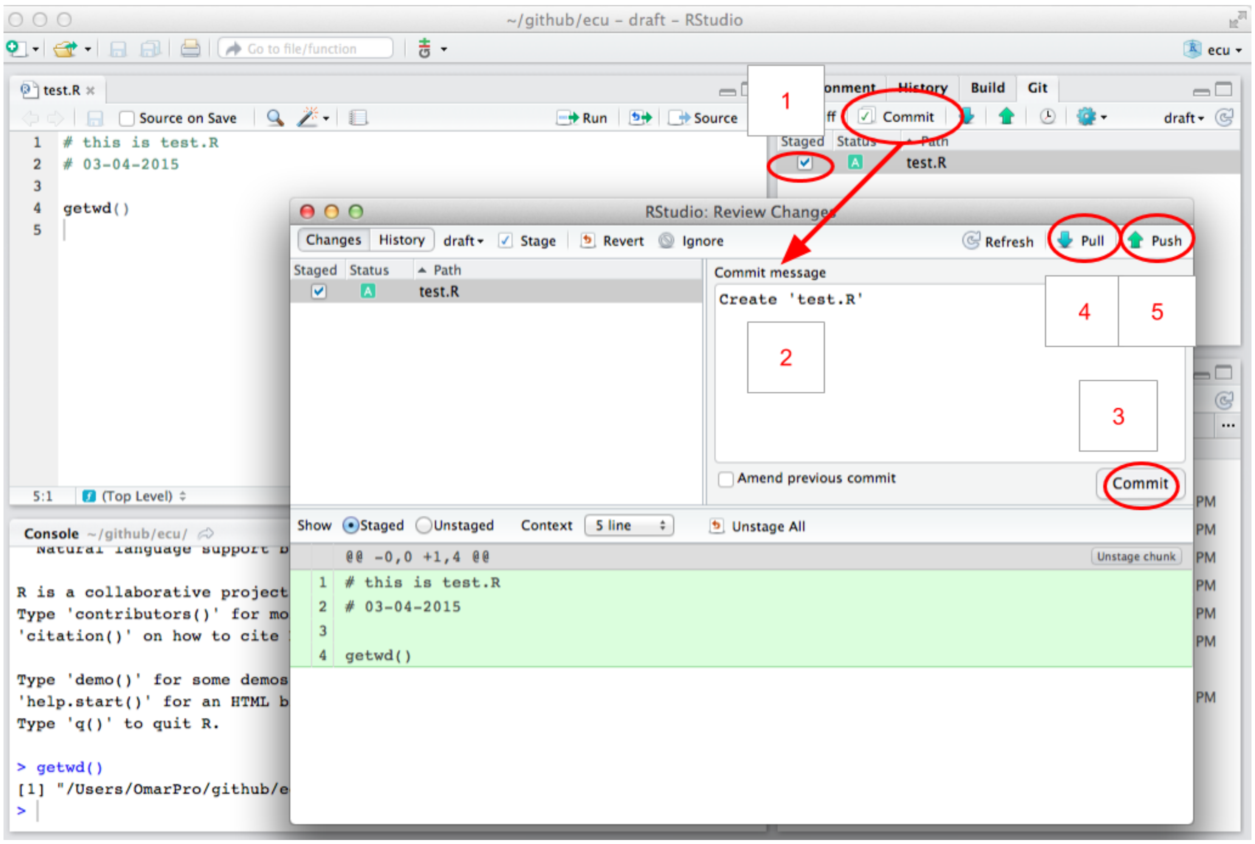


Figure 37: Figure showing RStudio when sycing. After first staging your changes, click the 'commit' button to open a new window where you can enter a 'commit message' and then pull and push new changes.

TIP: Another way to sync and open the project is to click on 'New Project' in the upper-right-hand corner of Rstudio, then choose 'Version Control', and then you can paste the URL of the desired repository. This URL can be found on on your online repository's homepage.

6.3.13 Install the latest version of R and RStudio

Make sure you have the most current version of R and RStudio. Download **R** at http://cran.r-project.org/ and install on your computer. If you already have R installed, check the website for updates. There are frequent updates to the R software, and the current version is identified on the website. Compare what is available from their website with what you already have on your computer by typing `sessionInfo()` into your R console. (This will also identify packages you have installed).

While not required, we highly recommend working with **RStudio**, which is an interface that makes working with R much easier, and it also interfaces with GitHub so you are able to synchronize without using the GitHub App. RStudio does not get updated as often as R does, but it is good to check for updates regularly.

6.4 GitHub repository architecture

GitHub stores all data files and scripts for your assessment in a repository (a folder). Different copies or complements to these folders, called *branches* can also exist, which aid with versioning and drafting. Your repository has four branches, two of which are displayed on your website (e.g., ohi-science.org/ecu):

1. **draft** branch is for editing. This is the default branch and the main working area where existing scenario data files can be edited and new scenarios added.
2. **published** branch is a vetted copy of the draft branch, not for direct editing. This branch is only updated by automatic calculation of scores if:
    1. no errors occur during the calculation of scores in the draft branch, and
    2. publishing is turned on. During the draft editing and testing phases of development, it is typically desirable to turn this off.
3. **gh-pages** branch is this website. The results sections of the site (regions, layers, goals, scores per branch/scenario) are overwritten into this repository after automatic calculation of scores. The rest of the site can be manually altered.
4. **app** branch is the interactive layer and map viewer application. The user interface and server-side processing use the Shiny R package and are deployed online via ShinyApps.io to your website. Once deployed, the WebApp pulls updates from the data branches (draft and published) every time a new connection is initiated (i.e., browser refreshes).

    TIP: When looking at files on GitHub, note that the timestamps are associated with the 'commit' time rather than the 'push' time.

7 Using the Toolbox

> **Section Summary:**
>
> In this section, you will learn about the most common modifications made to repositories. You will be given examples to follow to help with your own assessment. The most common modifications are changing the pressures and resilience matrices, changing or creating data layers, and changing or removing goals models.
>
> TIP: You should now have your assessment repository opened and be familiar with the files in the folder.

As your team finalizes which data should be included in the assessment and begins developing goal models, you can incorporate this information into your repository. Data layer files can be created and updated with any software that handles *.csv* files, but goal models must be updated in R. With any modifications you sync to the online repository, the Toolbox will automatically recalculate goal scores. Calculations can also be done locally and offline by running `subcountry2014/calculate_scores.R`.

This section gives instruction and examples for the most common modifications you will make to your repository:

- **modifying pressures and resilience matrices**
- **modifying and creating data layers for status, trend, pressures and resilience**
- **modifying goal models**
- **removing goals**

The files you will modify are:

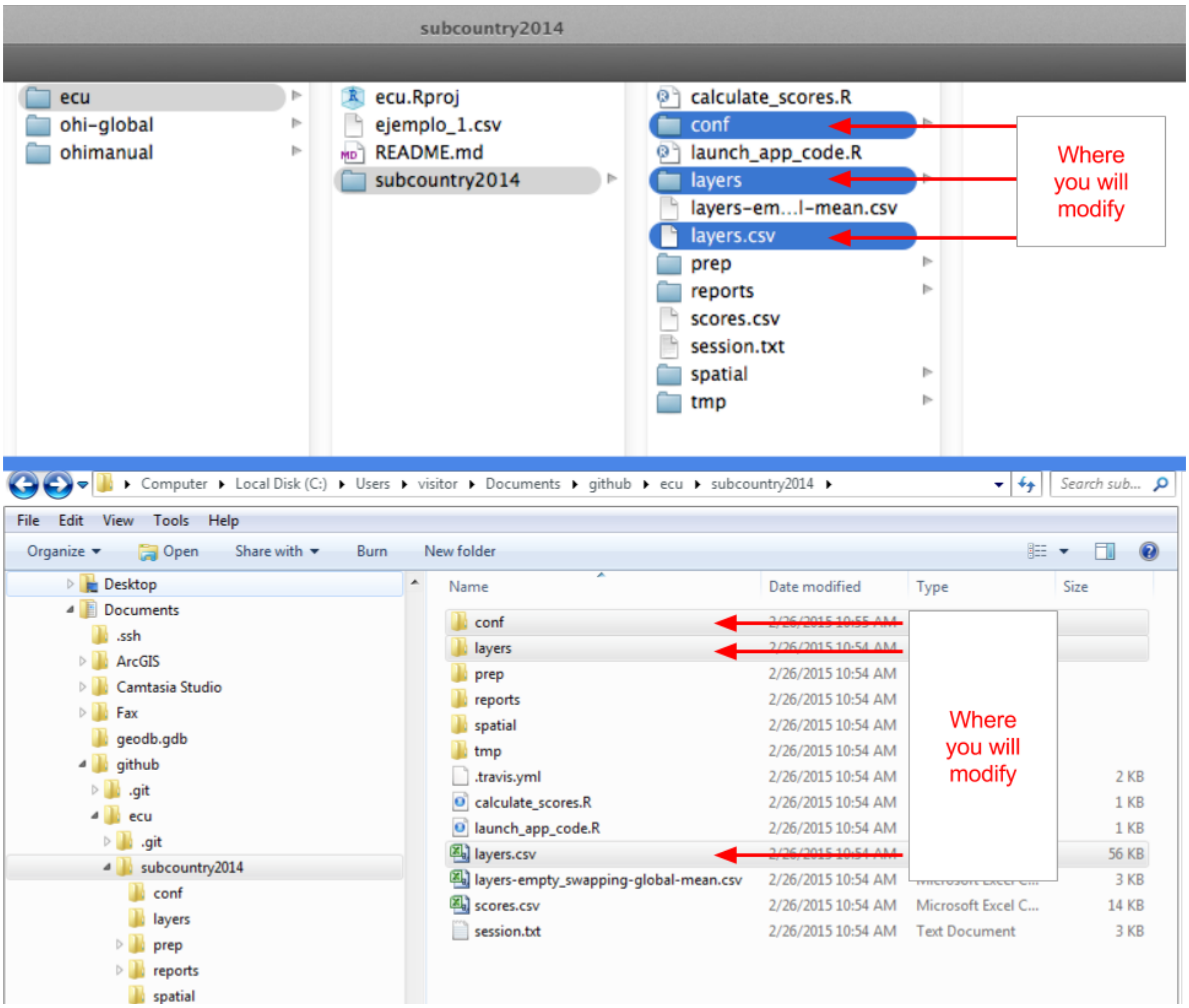


Figure 38: Files you will commonly modify are shown in the figure (Mac navigation is shown above and Windows is shown below). These include the `conf` folder, `layers` folder, and `layers.csv`.

7.1 Modifying and creating data layers

Data layers are *.csv* files and are located in the `[assessment]/subcountry2014/layers` folder. Remember that all data layers provided in your repository are extracted from the global 2014 assessment.

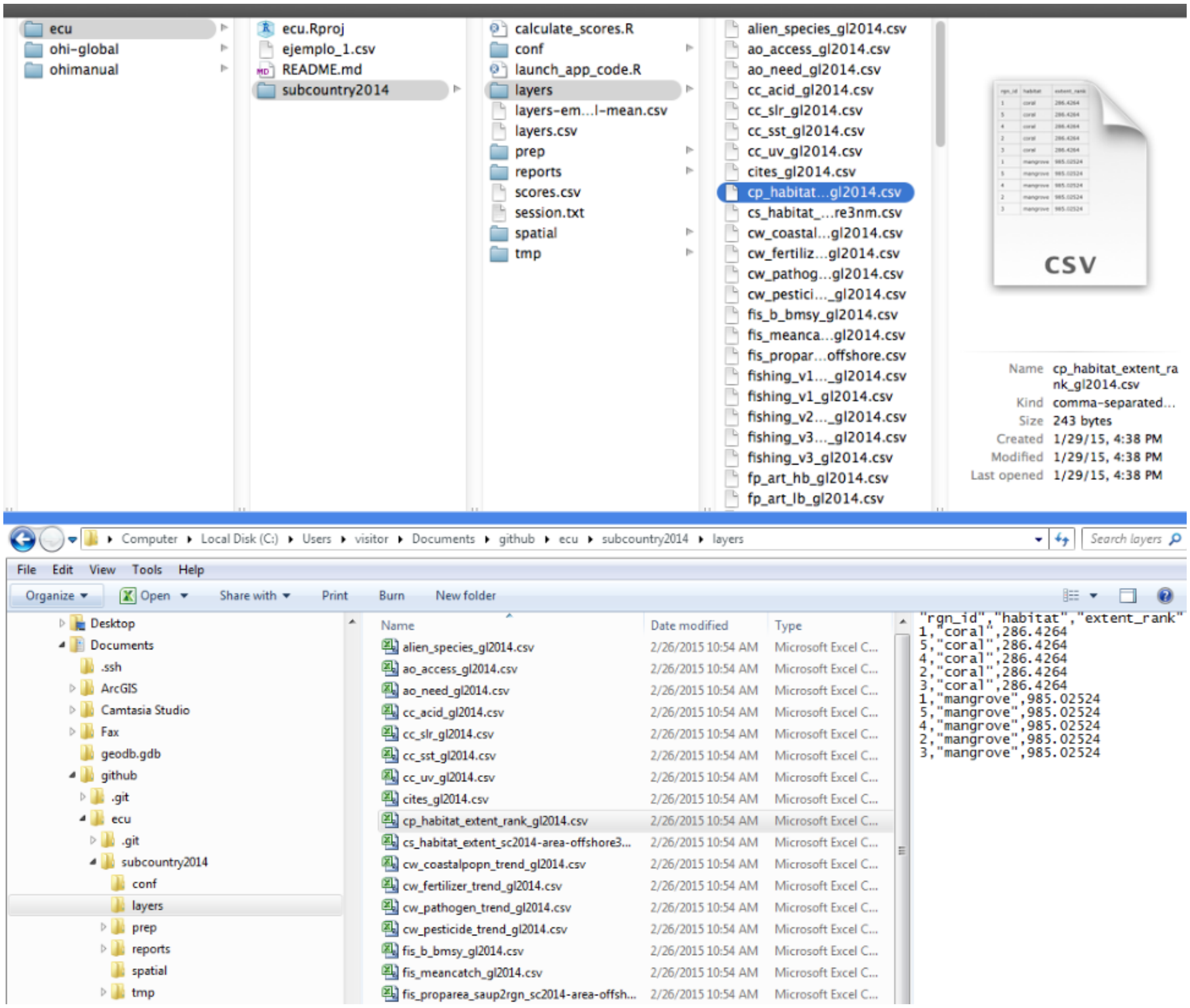


Figure 39: This figure shows the location of your data layers. Mac navigation is shown above and Windows is shown below.

- Layers with the suffix `_gl2014.csv` (*gl* for *global*) have been exactly copied from the global assessment and applied equally to each region, and therefore the values will be the same across all subcountry regions.
- Layers with the suffix `_sc2014.csv` (*sc* for *subcountry*) have been spatially-extracted from global data or adjusted with spatially-extracted data so that each region in your assessment has a unique value. For example, gross domestic product (GDP) used in the global assessment was reported at the national (most often country) level. Instead of being applied equally across all subcountry regions (which would incorrectly increase the nation's GDP several times), national GDP was down-weighted by the proportion of coastal population in each region compared with the total coastal population.

Both types of default data layers are of coarse-resolution and should be replaced with local, high-resolution data when possible. The priority should be to replace as much of the `_gl2014.csv` data as possible.

There are several steps to follow when working with data layers:

1. Modify or create data layer with proper formatting
2. Save the layer in the `layers` folder
3. Register the layer in `layers.csv`
4. Check (and update when appropriate) `pressures_matrix.csv` and `resilience_matrix.csv` (located in: `[assessment]/subcountry2014/conf`)

7.1.1 Create data layers with proper formatting

The OHI Toolbox expects each data layer to be in its own *.csv* file and to be in a specific format, with data available for every region within the study area, with data organized in 'long' format (as few columns as possible), and with a unique region identifier (*rgn_id*) associated with a single score or value. See the **'Formatting data for the Toolbox'** section for more information.

7.1.2 Save data layers in the *layers* folder

When you modify existing or create new data layers, we recommend saving this as a new *.csv* file with a suffix identifying your assessment (example: `_sc2014.csv`). Modifying the layer name provides an easy way to track which data layers have been updated regionally, and which rely on global data. Then, the original layers (`_gl2014.csv` and `_sc2014.csv`) can be deleted.

* Note: filenames should not have any spaces: use an underscore ('_') instead. This will reduce problems when R reads the files.

7.1.3 Register data layers in `layers.csv`

When there are new filenames associated with each layer, they will need to be registered in `[assessment]/subcountry2014/layers.csv`. If a layer simply has a new filename, only the *filename* column needs to be updated:

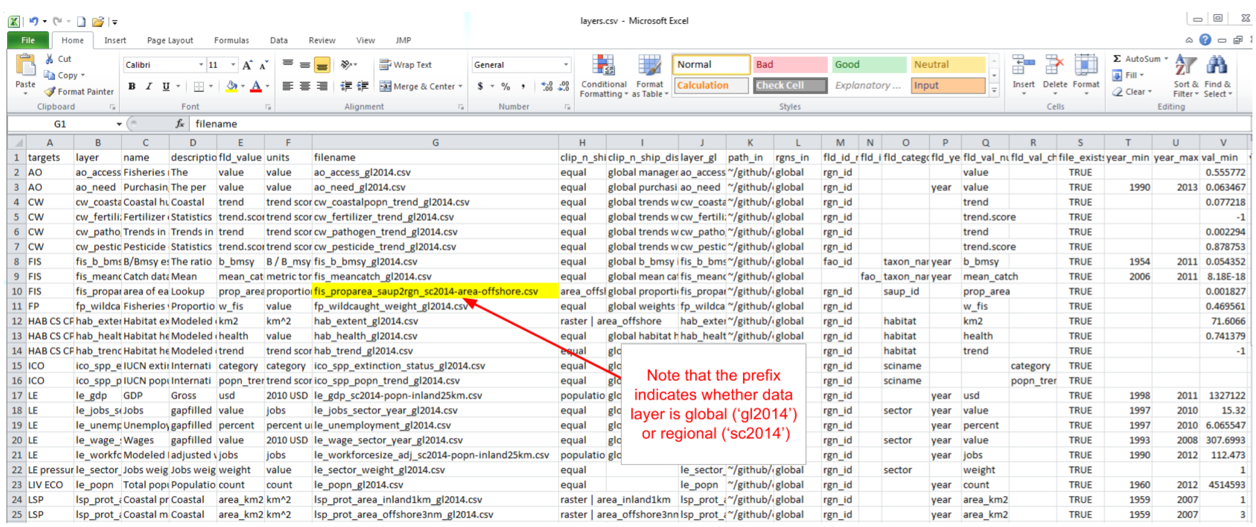


Figure 40: Register new layers in `layers.csv`. Be sure to note if there is a change in the filename.

TIP: This part is done manually. If you prefer not to manipulate your file by hand, you can generate a script that automates this.

However, if a new layer has been added (for example when a new goal model is developed), you will need to add a new row in the registry for the new data layer and fill in the first eight columns (columns A-H); other columns are generated later by the Toolbox as it confirms data formatting and content:

- **targets:** Add the goal/dimension that the new data layer relates to. Goals are indicated with two-letter codes and sub-goals are indicated with three-letter codes, with pressures, resilience, and spatial layers indicated separately.
- **layer:** Add an identifying name for the new data layer, which will be used in R scripts like `functions.R` and *.csv* files like `pressures_matrix.csv` and `resilience_matrix.csv`.
- **name:** Add a longer title for the data layer–this will be displayed on your WebApp.
- **description:** Add a longer description of the new data layer–this will be displayed on your WebApp.
- **fld_value:** Add the appropriate units for the new data layer (which will be referenced in subsequent calculations).
- **units:** Add a description about the *units* chosen in the *fld_value* column above.
- **filename:** Add a filename for the new data layer that matches the name of the *.csv* file that was created previously in the `layers` folder.
- **fld_id_num:** Area designation that applies to the newly created data layer, such as: *rgn_id* and *fao_id*.

7.1.4 Check pressures and resilience matrices

If the new or modified layer is a pressures layer, check that `pressures_matrix.csv` and `resilience_matrix.csv` have been properly modified to register the new data layers.

7.2 Modifying pressures matrices

Your team will identify if any pressures layers should be added to the pressures matrices, and if so, which goals the pressure affects and what weight they should have. You can transfer this information in `pressures_matrix.csv` (located in the `[assessment]/subcountry2014/conf` folder). It is important to note that the matrix identifies the pressures relevant to each goal, and which weight will be applied in the calculation. Each pressure is a data layer, located in the `subcountry2014/layers` folder. This means that pressure layers need information for each region in the study area, and some layers will need to be updated with local data. In modifying pressures, you will need to consider whether data layers can be updated or added, and whether data layers map onto goals appropriately in the local context.

Adding a new pressure to the pressures matrix requires the following steps:

1. Create new pressure layer(s) and save in the `layers` folder
2. Register pressure layer(s) in `layers.csv`
3. Register pressure layer(s) in `pressures_matrix.csv`

- a. Set the pressure category

- b. Identify the goals affected and set the weighting
- c. Modify the resilience matrix (if necessary)

The following is an example of adding two new pressures layers.

7.2.1 Create the new pressure layers and save in the `layers` folder

If you create a new data layer, give it a short but descriptive name that also includes a prefix that signifies the pressure category (for example: *po_* for the pollution category). There are five physical categories and one social category:

- *po_* = pollution
- *hd_* = habitat destruction
- *fp_* = fishing pressure
- *sp_* = species pollution
- *cc_* = climate change
- *ss_* = social pressure

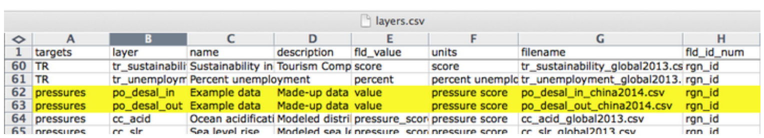
So for example, `po_trash` is a pollution layer with trash on beaches, and `sp_alien` is species pollution due to alien (invasive) species.

In the current example, the two new layers created to account for the input and output effects of desalination operations will be called *po_desal_in*, and *po_desal_out*.

These new layers will have scores from 0 to 1, with values for each region in your study area, and will be saved in the `layers` folder.

7.2.2 Register the new pressure layers in `layers.csv`

Add two new rows in `layers.csv`, and register the new pressure layers by filling out the first eight columns for *po_desal_in*, and *po_desal_out*.


layers.csv

	A	B	C	D	E	F	G	H
1	targets	layer	name	description	fld_value	units	filename	fld_id_num
60	TR	tr_sustainabili	Sustainability in	Tourism Comp	score	score	tr_sustainability_global2013.cs	rgn_id
61	TR	tr_unemploym	Percent unemployment		percent	percent unemplo	tr_unemployment_global2013.	rgn_id
62	pressures	po_desal_in	Example data	Made-up data	value	pressure score	po_desal_in_china2014.csv	rgn_id
63	pressures	po_desal_out	Example data	Made-up data	value	pressure score	po_desal_out_china2014.csv	rgn_id
64	pressures	cc_acid	Ocean acidificati	Modeled distri	pressure_scor	pressure score	cc_acid_global2013.csv	rgn_id
65	pressures	cc_slr	Sea level rise	Modeled sea l	pressure_scor	pressure score	cc_slr_global2013.csv	rgn_id

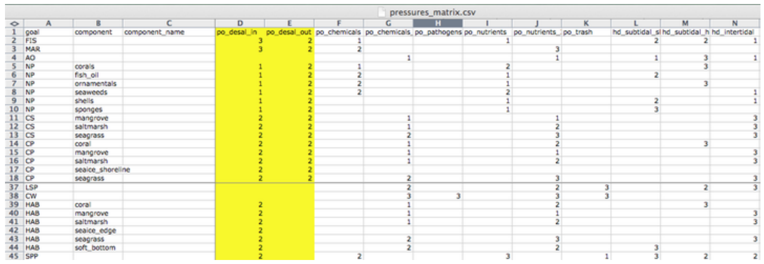
Figure 41:

7.2.3 Register the new layers in `pressure_matrix.csv`

`pressures_matrix.csv` identifies the different types of ocean pressures (columns) with the goals that they affect (rows). Adding a new pressures layer to `pressures_matrix.csv` requires adding a new column with the pressure layer name.

7.2.3.1 Set the pressure category This step requires transferring previous decisions made by your team into `pressures_matrix.csv`. Each pressure category is calculated separately before being combined with the others, so it is important to register the new pressure with the appropriate category prefix decided by your regional assessment team.

7.2.3.2 Identify the goals affected and set the weighting This step also requires transferring prior decisions into `pressures_matrix.csv`. Mark which goals are affected by this new pressure, and then set the weighting. Pressures weighting by goal should be based on scientific literature and expert opinion (3 = highly influential pressure, 2 = moderately influential pressure, 1 = not very influential pressure). Remember that the rankings in the pressures matrix are separate from the actual data within the pressures data layers. The rankings ensure that within a particular goal (e.g. within a row of the pressures matrix), the stressors that more strongly influence the goal's delivery have a larger contribution to that goal's overall pressure score. Therefore, the rankings are assigned independently of the actual pressure scores, and only determine their importance within the calculations.



pressures_matrix.csv

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	goal	component	component_name	po_desal_in	po_desal_out	po_chemicals	po_chemicals_	po_pathogens	po_nutrients	po_nutrients_	po_trash	hd_subtidal_sl	hd_subtidal_h	hd_intertidal
2	FIS			3	2	1			1			2	2	1
3	MAR			3	2	2				3				
4	AO						1			1		1	3	1
5	NP	corals		1	2	1			2				3	
6	NP	fish_oil		1	2	2			1			2		
7	NP	ornamentals		1	2	2			1				3	
8	NP	seaweeds		1	2	2			2					1
9	NP	shells		1	2				1			2		1
10	NP	sponges		1	2				1			3		
11	CS	mangrove		2	2		1			1				3
12	CS	saltmarsh		2	2		1			2				3
13	CS	seagrass		2	2		2			3				3
14	CP	coral		2	2		1			2			3	
15	CP	mangrove		2	2		1			1				3
16	CP	saltmarsh		2	2		1			2				3
17	CP	seaice_shoreline		2	2									
18	CP	seagrass		2	2		2			3				3
37	LSP						2			2	3		2	3
38	CW						3	3		3	3			
39	HAB	coral		2			1			2			3	
40	HAB	mangrove		2			1			1				3
41	HAB	saltmarsh		2			1			2				3
42	HAB	seaice_edge		2										
43	HAB	seagrass		2			2			3				3
44	HAB	soft_bottom		2			2			2		3		
45	SPP			2		2			3		1	3	2	2

Figure 42:

7.2.4 Modify the resilience matrix (if necessary)

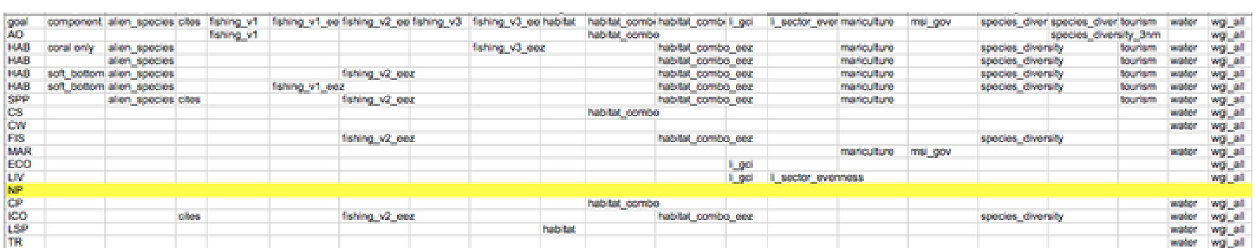
Resilience is included in OHI as the sum of the ecological factors and social initiatives (policies, laws, etc.) that can positively affect goal scores by reducing or eliminating pressures. The addition of new pressure layers may therefore warrant the addition of new resilience layers that were not previously relevant. Similarly, the removal of pressure layers may warrant the removal of now irrelevant resilience layers.

7.3 Modifying resilience matrices

Previous decisions made with your team will identify if any resilience layers should be added to the resilience matrices, and if so, which goals and/or pressures the resilience affects and what weight they should have. You can then transfer this information into `resilience_matrix.csv` (located in the `[assessment]/subcountry2014/conf` folder).

`resilience_matrix.csv` maps the different types of resilience (columns) with the goals that they affect (rows). New resilience layers may be added to `resilience_matrix.csv` based on finer-scale local information either in response to a new pressures layer, or as a new independent measure. Any added layer must be associated with a pressures layer that has a weight of 2 or 3 in the OHI framework so that resilience measures can mitigate pressures in each region.

Each goal must have a resilience measure associated with it. In the figure below, the Toolbox would give an error because there are no resilience layers indicated for the natural products (NP) goal.



goal	component	alien_species	cites	fishing_v1	fishing_v1_ee	fishing_v2_ee	fishing_v3	fishing_v3_ee	habitat	habitat_combo	habitat_combo	li_gci	li_sector_ever	mariculture	msi_gov	species_diver	species_diver	tourism	water	wgi_all
AO				fishing_v1						habitat_combo							species_diversity_3nm			wgi_all
HAB	coral only	alien_species						fishing_v3_eez			habitat_combo_eez			mariculture		species_diversity		tourism	water	wgi_all
HAB		alien_species									habitat_combo_eez			mariculture		species_diversity		tourism	water	wgi_all
HAB	soft_bottom	alien_species				fishing_v2_eez					habitat_combo_eez			mariculture		species_diversity		tourism	water	wgi_all
HAB	soft_bottom	alien_species			fishing_v1_eez						habitat_combo_eez			mariculture		species_diversity		tourism	water	wgi_all
SPP		alien_species	cites			fishing_v2_eez					habitat_combo_eez			mariculture				tourism	water	wgi_all
CS										habitat_combo									water	wgi_all
CW																			water	wgi_all
FIS						fishing_v2_eez					habitat_combo_eez					species_diversity				wgi_all
MAR														mariculture	msi_gov				water	wgi_all
ECO												li_gci								wgi_all
LIV												li_gci	li_sector_evenness							wgi_all
NP																				
CP										habitat_combo									water	wgi_all
ICO			cites			fishing_v2_eez					habitat_combo_eez					species_diversity			water	wgi_all
LSP									habitat										water	wgi_all
TR																			water	wgi_all

Figure 43:

7.3.1 Updating resilience matrix with local habitat information

In this example we will borrow from the experience of `ohi-israel`, where they assessed habitats in the Habitats (HAB) sub-goal that were not included in global assessments `ohi-global`. Therefore, the resilience matrix needed some revision.

The habitats assessed for `ohi-israel` are:

> `rocky_reef`, `sand_dunes`, `soft_bottom`

Updates are required for the following files:

- *layers.csv*
- *resilience_matrix.csv*
- *resilience_weights.csv* (only if adding new resilience layers)

7.3.1.1 Global resilience layers The first step is to determine which resilience layers from the global assessment are relevant to your assessment, and whether others need to be added. The full list of layers included in the global resilience matrix are:

> `alien_species`, `cites`, `fishing_v1`, `fishing_v1_eez`, `fishing_v2_eez`, `fishing_v3`, `fishing_v3_eez`, `habitat`, `habitat_combo`, `habitat_combo_eez`, `li_gci`, `li_sector_evenness`, `mariculture`, `msi_gov`, `species_diversity`, `species_diversity_3nm`, `tourism`, `water`, `wgi_all`

Some of these layers capture general aspects of governance that apply to the protection of any habitat. These are:

> `alien_species`, `cites`, `msi_gov`, `water`, `wgi_all`

Two layers only apply to the livelihoods and economies goal (LE), so they should be excluded from HAB resilience:

> `li_gci`, `li_sector_evenness`

The remaining layers apply to certain habitats, but not others. We focus on these to determine how to adapt the HAB resilience calculation for `ohi-israel`. They are:

> `fishing_v1`, `fishing_v1_eez`, `fishing_v2_eez`, `fishing_v3`, `fishing_v3_eez`, `habitat`, `habitat_combo`, `habitat_combo_eez`, `mariculture`, `species_diversity`, `species_diversity_3nm`, `tourism`

7.3.1.2 Determining how to modify these resilience layers

- To determine whether `species_diversity_3nm` or `species_diversity` should be used:
  - `sand_dunes` should use `species_diversity_3nm`,
  - `soft_bottom` should use `species_diversity`,
  - is `rocky_reef` mainly coastal? if so it should use `tourism` and `species_diversity_3nm`.
- If the habitats can be affected by mariculture plants (e.g. eutrophication and decreased water quality can occur if mariculture plants are close by and have poor wastewater treatment), then the `mariculture` resilience score should be added.
  - are there any mariculture plants in Israel? If yes, on which habitats do they occur?
- The remaining layers are the `fishing_v...` and `habitat..` layers, which are composite indicators obtained from different combinations of the following indicators:

`Mora, Mora_s4, CBD_hab, MPA_coast, MPA_eez`,

where:

- `Mora` is a fisheries governance effectiveness indicator by Mora *et al* (2009)
- `Mora_s4` is another indicator from Figure S4 of the supplementary material of the same publication that focuses on regulations of artisanal and recreational fisheries
- `CBD_hab` is a score assigned based on answers to a questionnaire compiled by countries that committed to Rio's Convention on Biological Diversity (CBD) to establish their progress towards habitat biodiversity protection
- `MPA_coast` is an indicator obtained as the proportion of coastal (3nm) waters that are in a marine protected area (MPA), with the maximum being 30% of coastal waters
- `MPA_eez` is an indicator obtained as the proportion of the whole EEZ that is in a marine protected area, with the maximum being 30% of the whole EEZ.

This table shows which indicators are used by each combo layer:

Layer	Mora	Mora_s4	CBD_hab	MPA_coast	MPA_eez
fishing_v1	Mora		CBD_hab	MPA_coast	
fishing_v1_eez	Mora		CBD_hab		MPA_eez
fishing_v2_eez	Mora	Mora_s4	CBD_hab		MPA_eez
fishing_v3		Mora_s4	CBD_hab	MPA_coast	
fishing_v3_eez		Mora_s4	CBD_hab		MPA_eez
habitat			CBD_hab		
habitat_combo			CBD_hab	MPA_coast	
habitat_combo_eez			CBD_hab		MPA_eez

Questions to consider:

The first objective is to determine whether the general `fishing_v..` or `habitat_...` categories are relevant to each of the habitats. For example, fisheries regulations do not affect the conservation of sand dunes, so this habitat should not use any of the fisheries combos. If the general resilience categories are relevant to the habitat, the next step is to select one resilience layer within the `fishing_v...` and `habitat...` categories that most adequately captures the suite of combined resilience variables that affect the habitat. For example, the sand dune habitat is a strictly coastal habitat, so the most appropriate resilience layer would be the one that uses the MPA_coast (i.e., `habitat_combo`). The rocky reef and soft bottom, on the other hand, should definitely include fisheries and habitat regulations. So, you'll need to choose a fisheries and a habitat combo for these two habitats. To do so, consider:

1) For which habitats should you use both a fishery and a habitat combo, or just use a habitat combo?

- fisheries regulations do not affect the conservation of sand-dunes, so this habitat should not use any of the fisheries combos. Also, this is a strictly coastal habitat, so choose the habitat layer that uses the `MPA_coast` instead of the `MPA_eez`, i.e. `habitat_combo` (and, as mentioned above, choose the coastal version of biodiversity, i.e. `species_diversity_3nm`).
- The rocky reef and soft bottom, on the other hand, should definitely include fisheries regulations. So you'll need to choose a fisheries and a habitat combo for these two habitats.

2) Which fisheries and habitat combos for `rocky_reef` and `soft_bottom`? The choice depends on two things:

- whether they are coastal habitats (within 3nm of the coast) or EEZ-wide habitats
  - if coastal, use the fisheries and habitat combos with `MPA_coast` (`fishing_v1`, `fishing_v3`, `habitat_combo`), and the `species_diversity_3nm` layer
  - if EEZ-wide, use the fisheries and habitat combos with `MPA_eez` (`fishing_v1_eez`, `fishing_v2_eez`, `fishing_v3_eez`, `habitat_combo_eez`), and the `species_diversity` layer
- whether the fisheries occurring on that habitat are mainly artisanal, mainly commercial, or both
  - if only commercial fisheries, use a layer that only uses the `Mora` data `fishing_v1..`)
  - if only artisanal/small-scale fisheries, use a layer that only uses the `Mora_s4` data (`fishing_v3..`)
  - if both, use a layer that uses both `Mora` and `Mora_s4` data (`fishing_v2..`)

3) It may also be that the existing global combo layers are not appropriate for your habitats. For example, if rocky reef is mainly coastal, and it is fished by both commercial and artisanal methods, then we need a new combo that uses `Mora`, `Mora_s4`, `CBD_hab`, and `MPA_coast` (this is the same as `fishing_v2_eez`, but we use the `MPA_coast` layer instead of the `MPA_eez`). All other combinations are already present.
4) Another issue to consider is whether local data are available to improve the pressure layers (that are based on global data). For example, if there are local data on Marine Protected Areas (MPAs) and any areas with special regulations, this should be used to generate the `MPA_coast` and `MPA_eez` layers.You may know that only certain types of protected areas are closed to fisheries, and may want to only include those. Also, local datasets may be more accurate and regularly updated. **NOTE: in the global study, these are the same datasets used to calculate the status of Lasting Special Places (LSP).
5) How to update `resilience_matrix.csv`?

- write the complete list of layers you want to use for each habitat. Based on the above, for example, `soft bottom` in Israel matches the combination of layers called *soft bottom, with corals* in the default `resilience_matrix.csv`. But the `rocky_reef` and `sand_dunes` don't seem to match any existing combination, so you'll probably need to delete some of the rows, e.g. the *coral only*, and replace with new ad-hoc rows.

7.4 Modifying goal models

When an existing layer is updated with new data, the Toolbox will automatically incorporate it into the goal calculations after the updated filenames are registered in `layers.csv`. However, if a new layer has been added to the layers folder and registered in `layers.csv`, the Toolbox will not use it unless it is called in a goal model. To integrate any new data layers registered in `layers.csv` you will need to modify the goal model to incorporate the data. Furthermore, in many cases, it will make sense to modify goal models based on data availability and/or local context. For example, the models for regional analyses can often be simplified because of improved data.

There are two steps to follow when working with goal models:

1. Update `functions.R`
2. Check and possibly update `goals.csv`

7.4.1 Update *functions.R*

To incorporate a new data layer into a goal model, open `functions.R` in RStudio: this script contains all the models for each goal and sub-goal. A member of your team with the ability to write R code will need to translate the updated goal model into the Toolbox format. Follow the structure of existing goal models in order to incorporate the new data layers, noting the use of certain R packages for data manipulation.

The image below shows the navigation pane in RStudio that can be used to easily navigate between goal models.

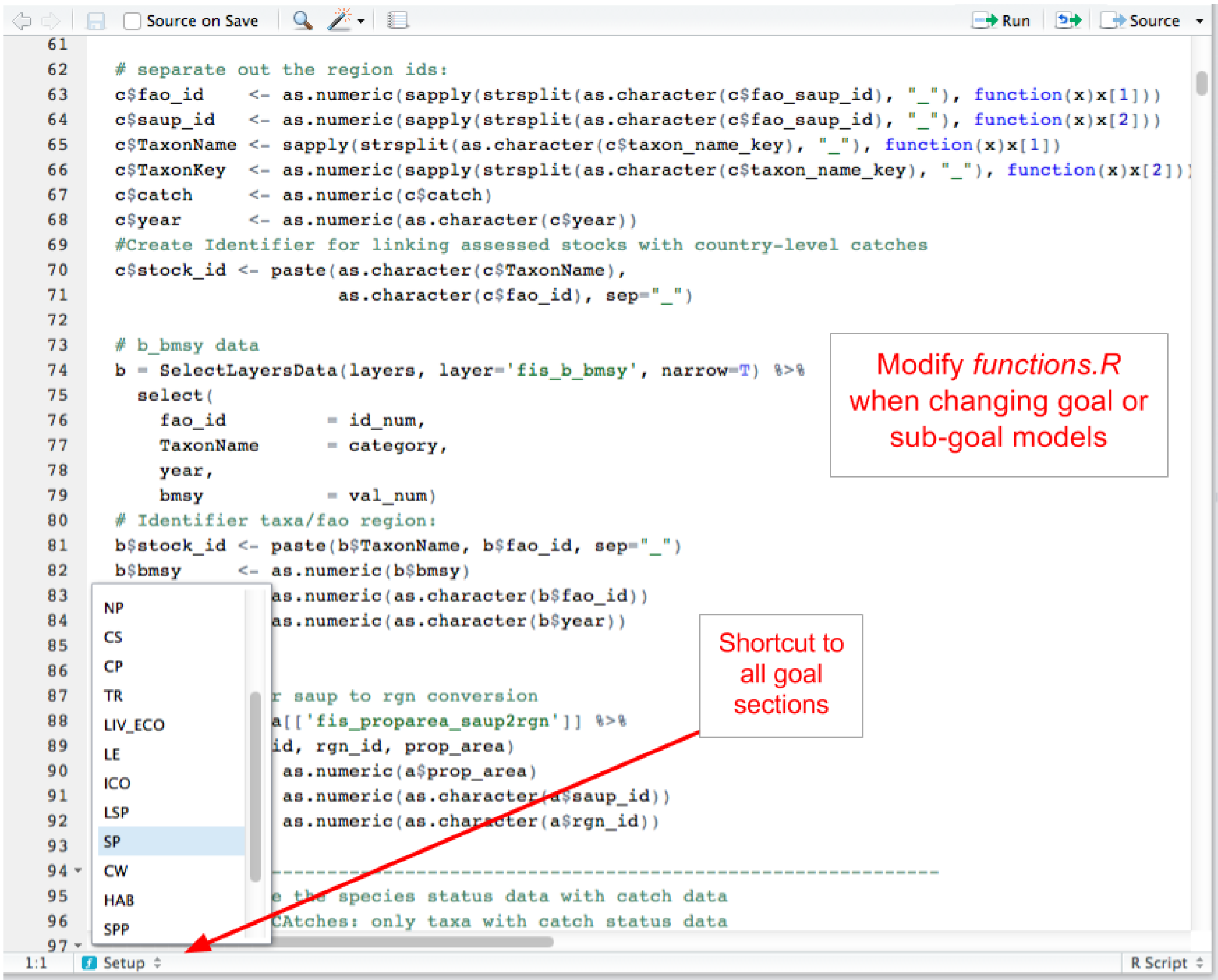


Figure 44: The navigation pane in RStudio can be used to easily navigate between goal models.

7.4.2 Check and possibly update *goals.csv*

`goals.csv` provides input information for `functions.R`, particularly about goal weighting and function calls. It also includes descriptions about goals and sub-goals, which is presented on the WebApp.

Changing goal weights will be done here by editing the value in the *weight* column. Weights do not need to be 0-1 or add up to 10; weights will be scaled as a proportion of the number of goals assessed. `goals.csv` also indicates the arguments passed to `functions.R`. These are indicated by two columns: *preindex_function* (functions for all goals that do not have sub-goals, and functions for all sub-goals) and *postindex_function* (functions for goals with sub-goals).

When updating layers or goal models, it is important to ensure that information called from `goals.csv` is correct:

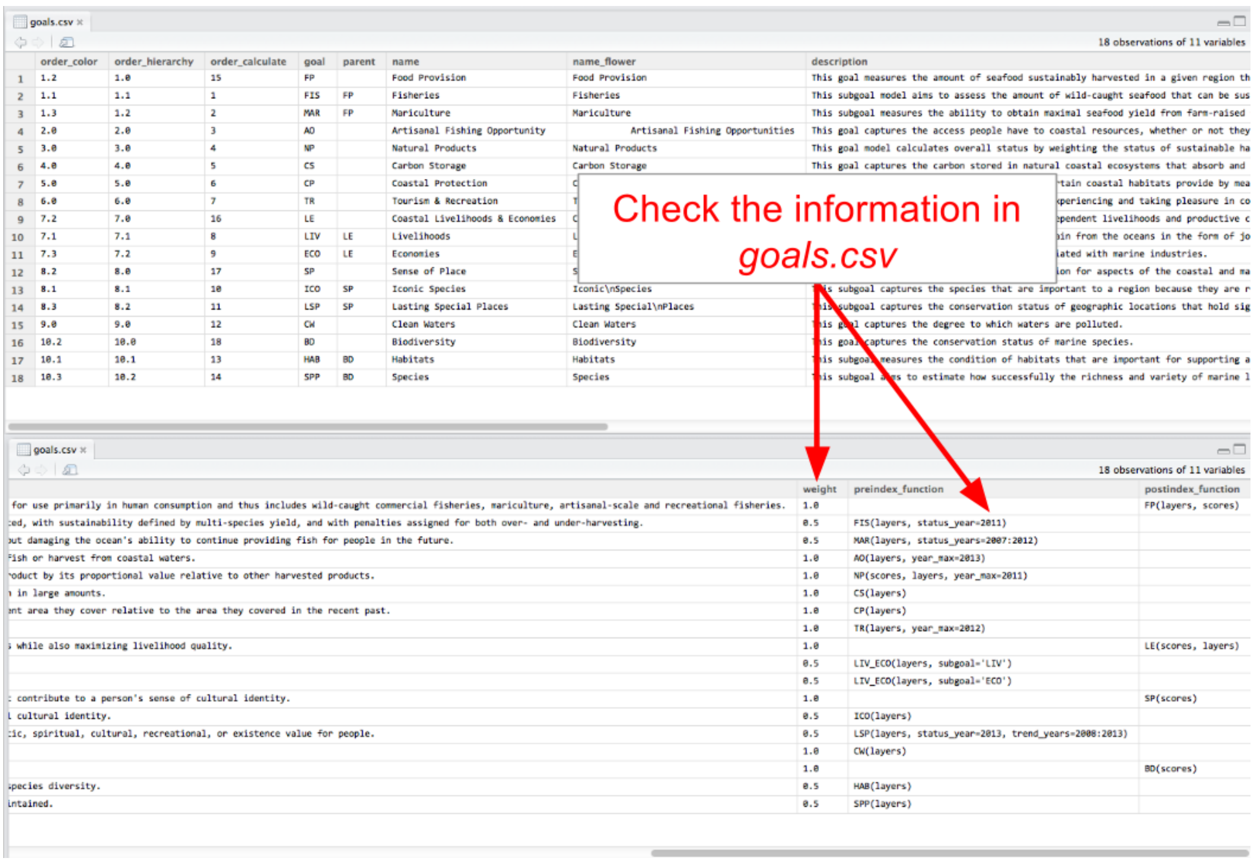


Figure 45: Check the information in `goals.csv`. It provides input information for `functions.R`.

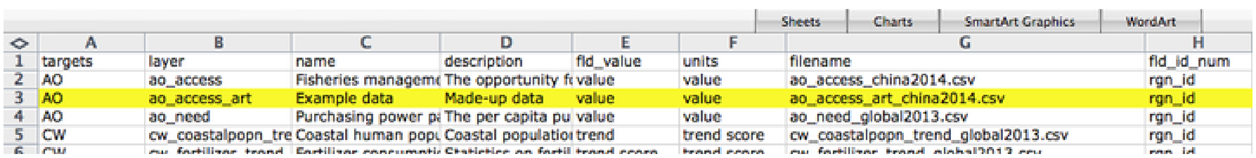
- check the years
- etc. . .

7.4.3 Example modification:

Suppose your team has decided to add an 'artisanal access' component to the Artisanal Fishing Opportunity goal because of locally available data. Once the data are obtained and properly formatted, the data layer is saved as `ao_access_art`. To include this new information in the goal model, you will need to do the following:

1. register the layer in `layers.csv`
2. update the goal model in `functions.R`
3. update the goal call in `goals.csv`

    1. register in `layers.csv`



	A	B	C	D	E	F	G	H
1	targets	layer	name	description	fld_value	units	filename	fld_id_num
2	AO	ao_access	Fisheries manageme	The opportunity fo	value	value	ao_access_china2014.csv	rgn_id
3	AO	ao_access_art	Example data	Made-up data	value	value	ao_access_art_china2014.csv	rgn_id
4	AO	ao_need	Purchasing power pa	The per capita pu	value	value	ao_need_global2013.csv	rgn_id
5	CW	cw_coastalpopn_tre	Coastal human popu	Coastal populatio	trend	trend score	cw_coastalpopn_trend_global2013.csv	rgn_id

Figure 46:

    2. update goal model

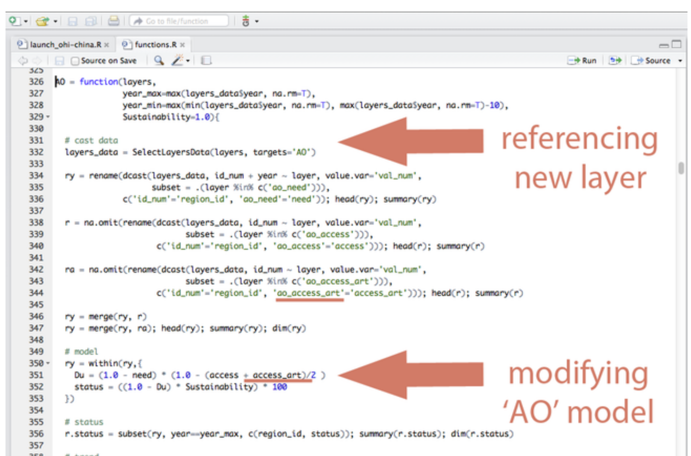


Figure 47:

    3. update goal call in `goals.csv`

[develop]

7.5 Removing goals

If a goal is not relevant in your region, it is possible to remove the goal completely from the calculation. There are four places where you will need to remove the reference to this goal. Failing to delete all referenced layers after the goal is deleted will result in errors. To remove goals from your assessment, you will have to do the following:

1. Remove the goal model from `functions.R`
2. Remove the goal's row from `goals.csv`
3. Remove the goal's row from `pressures_matrix.csv`
4. Remove the goal's row from `resilience_matrix.csv`

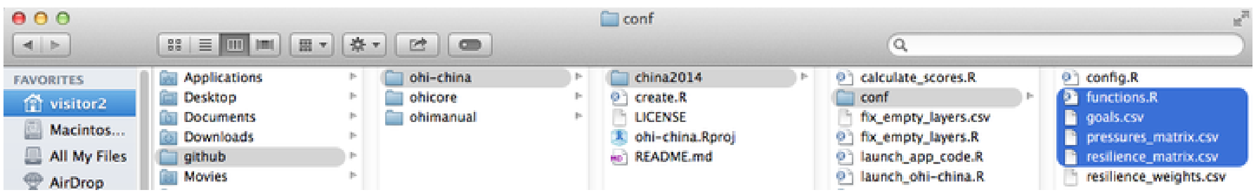


Figure 48:

Example: Removing carbon storage (CS) goal

To completely remove the carbon storage goal from Index calculations, you will do the following.

1) Remove the carbon storage (CS) goal model from `functions.R`. Delete the highlighted text in the figure below that references the CS layers and calculates CS goal status, trend, and scores.

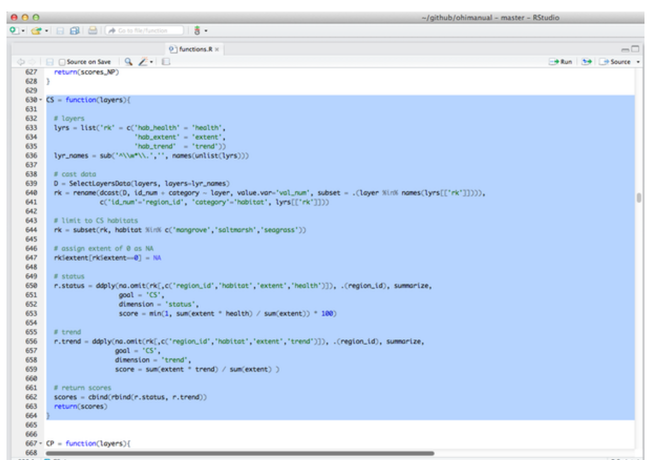
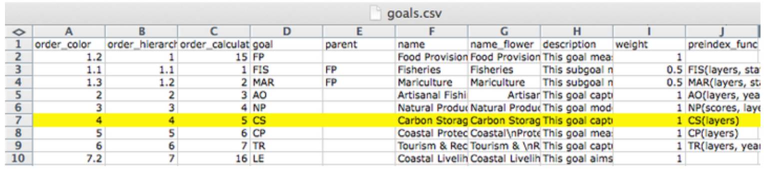


Figure 49:

2) Remove the CS row from `goals.csv`. Delete the highlighted row in the figure below that contains the CS goal.

3) Remove all CS rows from `pressures_matrix.csv`. Delete the highlighted rows in the figure below that contain CS pressures.

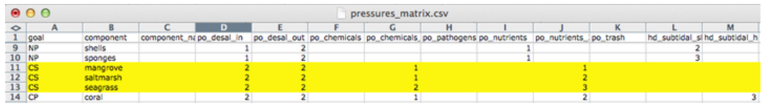
4) Remove all CS rows from `resilience_matrix.csv`. Delete the highlighted rows in the figure below that contain CS resilience.



goals.csv

	A	B	C	D	E	F	G	H	I	J
1	order_color	order_hierarch	order_calculat	goal	parent	name	name_flower	description	weight	preindex_func
2	1.2	1	15	FP		Food Provision	Food Provision	This goal mea:	1	
3	1.1	1.1	1	FIS	FP	Fisheries	Fisheries	This subgoal n	0.5	FIS(layers, sta
4	1.3	1.2	2	MAR	FP	Mariculture	Mariculture	This subgoal n	0.5	MAR(layers, st
5	2	2	3	AO		Artisanal Fishi	Artisar	This goal capt	1	AO(layers, yea
6	3	3	4	NP		Natural Produc	Natural Produc	This goal mod	1	NP(scores, laye
7	4	4	5	CS		Carbon Storag	Carbon Storag	This goal capt	1	CS(layers)
8	5	5	6	CP		Coastal Protec	Coastal\nProte	This goal mea:	1	CP(layers)
9	6	6	7	TR		Tourism & Rec	Tourism & \nR	This goal capt	1	TR(layers, yea
10	7.2	7	16	LE		Coastal Livelih	Coastal Livelih	This goal aims	1	

Figure 50:



pressures_matrix.csv

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	goal	component	component_na	po_desal_in	po_desal_out	po_chemicals	po_chemicals_	po_pathogens	po_nutrients	po_nutrients_	po_trash	hd_subtidal_sl	hd_subtidal_h
9	NP	shells		1	2				1			2	
10	NP	sponges		1	2				1			3	
11	CS	mangrove		2	2		1			1			
12	CS	saltmarsh		2	2		1			2			
13	CS	seagrass		2	2		2			3			
14	CP	coral		2	2		1			2			3

Figure 51:

7.6 Other example modifications

7.6.1 Preparing the fisheries sub-goal

Here is some background information about how to prepare fisheries data layers for the Toolbox.

Data layers used by the Toolbox:

- `fis_b_bmsy`
- `fis_meancatch`
- `fis_proparea_saup2rgn`
- `fp_wildcaught_weight`

7.6.1.1 Description of data layers `fis_b_bmsy`

- *for species*: B/Bmsy estimate (either from formal stock assessment, or from a data-poor method such as CMSY)

- *for genus/family/broader taxa*: the toolbox will use median B/Bmsy from species in that region + a penalty for not reporting at species level. In order for the code to assign the correct penalty, the taxa need to include a numerical code of 6 digits, where the first digit behaves like an ISSCAAP code (the standardized species codes used by FAO): 6 means species, 5 means genus, 4 to 1 are increasingly broad taxonomic groups

- *data source (for CMSY)*: catch time-series (at least 10 years of catch >0), species resilience (if available)

Example data:

fao_id	taxon_name	year	b_bmsy
51	Ablennes hians	1985	1.112412
51	Ablennes hians	1986	1.222996
51	Ablennes hians	1987	1.371058

NOTE: if a species that is caught in different sub-regions belongs to the same population, you don't want to split the catch among sub-regions, instead, you want to sum catch across all sub-regions, so you can calculate B/Bmsy for the whole population. For the global analysis we grouped all species catch by FAO major fishing area (www.fao.org/fishery/area/search/en), indicated in the column *fao_id*, assuming that all species caught within the same FAO area belonged to the same stock, while we assumed that the same species, if caught in a different fishing area, belonged to a separate stock.
Use *fao_id* as an identifier that separates different fisheries 'stocks' belonging to the same species.
If you don't have multiple stocks in your study area, set all *fao_id* = 1.

`fis_meancatch`:

fao_saup_id	taxon_name_key	year	mean_catch
37_8	Aristeus antennatus_690051	2014	14.24398116
37_8	Atherinidae_400218	2014	27.30120156
37_8	Balistes capriscus_607327	2014	3.247883895

The *taxon_name_key* column indicates the name of the species (e.g. Aristeus antennatus) and its 'taxonkey'. The taxonkey is a 6 digit numeric code used by the Sea Around Us Project, modified from FAO codes. The important element of this code is the first digit, because it reflects the taxonomic level (6=species, 5=genus, 4=family, etc.) of the reported catch.The toolbox uses this first digit to assign a score to all catch that was not reported at species level, taking the median of the B/Bmsy of assessed species, and adding a penalty that is increasingly strong for coarser taxa.

`fis_proparea_saup2rgn`:

- a conversion file that, for each region for which catch is reported, tells us what proportion of that region falls within each of the final OHI reporting regions.

Example data:

saup_id	rgn_id	prop_area
166	1	1.0
162	2	1.0
574	3	0.7
37	4	0.8

Specific instances:

only if catch is reported for different regions than the ones used for the OHI assessment: this should be calculated using spatial analyses of overlap of the spatial units at which catch is reported with the spatial units at which the OHI assessment will be reported. The global data was reported by subregions (*saup_id*) and in some cases multiple subregions were part of the same, larger EEZ. Since for OHI we wanted results by EEZ (*rgn_id*), in those cases we needed to combine results from the subregions to get the final score, based on their size relative to the total EEZ size (*prop_area*).
If catch is reported for the same areas for which OHI is calculated: then all the *prop_area* are = 1.
If catch is reported for the whole area of the assessment, but you want to calculate a separate OHI score for different sub-regions: for each OHI reporting region (*rgn_id*) you'll repeat the same region in the *saup_id* column, and *prop_area* will be =1. This effectively means all the reporting regions will get assigned 100% of the catch and will have the same final stastus and trend score for the fisheries goal (but may have different pressures and resilience scores, if those layers are different in each sub-region).

`fp_wildcaught_weight`:

only needed if there is mariculture: for each region, this represents the relative proportion of catch coming from wild caught fisheries versus mariculture. The layer is used to weight how much the fisheries score influences the final food provision score, the higher the fisheries catch, the more the food provision score will reflect the fisheries score, and vice-versa if mariculture has a higher catch.
(NOTE that, before all mariculture harvest from all species gets summed, the mariculture harvest for each species is smoothed and then multiplied by the resilience score).

7.6.1.2 Running CMSY model **Sample data to run CMSY:**

id	stock_id	res	ct	yr
6	Acanthistius brasilianus_41	Medium	100	1950
23	Acanthurus dussumieri_61		0.059250269	1950
24	Acanthurus dussumieri_71		0.190749971	1950
25	Acanthurus lineatus_61	Low	12.74821966	1950

The current CMSY script produces an output that looks something like this (split into 2 tables):

stock_id	convergence	effective_sample_size	yr	b_bmsy	b_bmsyUpper
Ablennes hians_51	SC	30974	1985	1.112412	1.8
Ablennes hians_51	SC	30974	1986	1.222996	1.768895

stock_id	yr	b_bmsyLower	b_bmsyiq25	b_bmsyiq75	b_bmsyGM	b_bmsyMed
Ablennes hians_51	1985	1	1	1	1.093932	1
Ablennes hians_51	1986	1.014688	1.075699	1.298437	1.209005	1.160329

where *stock_id* is the unique identifier for each stock that was used in the input file, *convergence* indicates whether the model converged and how strongly ('SC' = strong convergence), *effective_sample_size* reports the number of iterations used, *yr* = year, b_bmsy = B/Bmsy for the corresponding year (based on the median of all the estimated values: reccomended), b_bmsyUpper = B/Bmsy at the upper 95% bootstrapped confidence bound, b_bmsyLower = B/Bmsy at the lower 95% bootstrapped confidence bound, b_bmsyiq25 = B/Bmsy at the first quartile, b_bmsyiq75 = B/Bmsy at the third quartile, b_bmsyGM = B/Bmsy based on the geometric mean of estimates, b_bmsyMed = B/Bmsy based on the median of estimates.

How to:

1. Include resilience in the CMSY code:

In the CMSY R script, in the PARAMETERS section, replace the following:

```
start_r     <- c(0.01,10)  ## disable this line if you use resilience
with

  if(res == "Very low"){
    start_r  <- c(0.015, 0.1)
  } else {
    if(res == "Low"){
      start_r  <- c(0.05,0.5)
    } else {
      if(res == "High"){
        start_r  <- c(0.6,1.5)
      } else {
        start_r  <- c(0.1,1)
      }
    }
  }
```

Figure 53:

2. Make assumptions about fisheries regulations:

If you assume that fisheries are depleted and there isn't very much fisheries regulation, and you are using the CMSY method to assess B/Bmsy, the original model may work well. If, however, the catch of a species declined because fisheries regulations have closed or limited the fishery, or if a fishery was abandoned for

economic reasons (e.g., change in consumer prefereces, market price dynamics, etc.), the model may be too pessimistic and understimate B/Bmsy. In that case it may be best to use a version with a uniform prior on final biomass, instead of the constrained prior.
The original constrained prior on final biomass is set by this line within the code:

```
finalbio    <- if(ct[nyr]/max(ct) > 0.5) {c(0.3,0.7)} else {c(0.01,0.4)}
```

The model uses a uniform prior if that line is replaced with:

```
finalbio    <- c(0.01,0.7)
```

3. Use data at a different spatial resolution than the final assessment:

See notes above for `fis_proparea_saup2rgn`

4. Calculate B, or Bmsy:

The CMSY model calculates B/Bmsy as a ratio, it does not estimate the two variables separately.

5. Use catch per unit of effort (CPUE):

The CMSY model requires total biomass removed by fisheries, and uses catch as a proxy for that. It cannot use CPUE. Other more sophisticated stock assessment models use CPUE and may be employed. We do not provide documentation for the use of these other models.

6. Use other life-history characteristics, in addition to resilience:

The CMSY model does not use more detailed information. Other more sophisticated stock assessment models use other life-history traits such as fecundity, larval dispersal, r, K, Lmax, etc., and may be employed. We do not provide documentation for the use of these other models.

7. Create a 'taxonkey' to assign to each species:

When replacing the SAUP_FAO data with your own data, assign a key of 600000 to all species. For all catch that is reported at genus or coarser taxonomic level, you will have to choose an appropriate taxonkey. You can create your own key, from 100000 to 500000, based on your own judgment of how many species may be reported under that same denomination, and how different they may be (all that matters for the toolbox code is whether the number starts with a 1,2,3,4,5 or 6 with 1 being the coarsest, such as 'miscellaneous marine animals', or 'crustaceans nei').

7.6.1.3 Resources Martell, S & Froese, R (2013) "A simple method for estimating MSY from catch and resilience". *Fish and Fisheries*, DOI: 10.1111/j.1467-2979.2012.00485.x. Downloadable here

Rosenberg, A.A., Fogarty, M.J., Cooper, A.B., Dickey-Collas, M., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Kleisner, K.M., Kristiansen, T., Longo, C., Minte-Vera, C., Minto, C., Mosqueira, I., Chato Osio, G., Ovando, D., Selig, E.R., Thorson, J.T. & Ye, Y. (2014) Developing new approaches to global stock status assessment and fishery production potential of the seas. *FAO Fisheries and Aquaculture Circular No. 1086*. Rome, FAO. 175 pp. Downloadable here

7.7 Notes about R

The Toolbox is written in R, and relies heavily on a few R packages created to faciliate data handling and manipulation. The primary R package used is called `dplyr` by Hadley Wickham. The `dplyr` package allows for 'chaining' between functions, which is represented with a `%>%`. See: https://github.com/hadley/dplyr#dplyr for documentation.

8 Frequently Asked Questions (FAQs)

This document provides answers to some frequently asked questions about conducting regional assessments using the Ocean Health Index. A few questions are related to general concepts in the Ocean Health Index, but mostly those topics are covered at http://www.oceanhealthindex.org/About/FAQ/. Here, the FAQ are primarily technical questions regarding regional assessments and using the OHI Toolbox. This document will be updated continually as we have more questions. Questions are arranged by theme, and have the format Q: (question) and A: (answer).

8.1 Overall

8.2 Conceptual

Q: Are regional assessment scores comparable with global assessment scores?

A: Regional Index scores cannot be directly compared to global Index scores, or to other regional Index scores calculated through separate efforts. This is because data and indicators (both what they measure and their quality), reference points (set using local knowledge and priorities), and specific goal models are often different for the areas being compared.

However, because scores for each goal are scaled to a reference point, qualitative comparisons can be made. For example, a score of 71 in the US West Coast compared to 66 in Brazil says that the US West coast is closer to fully meeting its sustainable goals (i.e., meeting regional reference points). Furthermore, use of the same Ocean Health Index framework across regional assessments permits fruitful discussion and general comparisons even if data inputs differ. Ocean Health Index assessments at any scale always work within a standardized definition of ocean health, using information to capture the philosophy of the ten goals that have been identified (and undergone scientific peer-review) prior to compiling relevant data. Use of the ten-goal framework is important both to ensure that all aspects of ocean health are captured and to allow better comparison across regional assessments than would be possible if the different regions used different methods.

Q: Where is climate change measured in the Index?

A: Four different aspects of climate change − increases in sea surface temperature (SST), sea level rise (SLR), ultraviolet radiation (UV), and ocean acidification (OA) − are included as pressures to many goals in the Index, including Natural Products, Carbon Storage, Coastal Protection, Sense of Place, Livelihoods & Economies and Biodiversity. Mitigation of climate change through carbon storage is one of the ten goals.

Q: Why are food provision and artisanal fishing opportunities goals separated?

A: These goals measure different aspects of how people relate to fishing. The catch of fish made by artisanal (=small-scale, subsistence type) fisheries is captured in the food provision goal. Jobs, wages and income from both the food provision and artisanal fishing goals are captured in the livelihoods & economies goal. The purpose of the artisanal fishing opportunity goal is to evaluate the opportunity for people to pursue this fishing in relation to their need to do so.

8.3 Timing and Resources

Q: How much does it cost to produce a regional assessment?

A: Regional assessments can be completed at(varying costs depending on the local context.(Funds are needed for a management and scientific team, workshops and meetings (including travel), communications, policy engagement, and operating costs. Therefore, securing funding is an important component to satisfactorily complete the assessment. We encourage the development of a local proposal or strategic action plan that details a timeline of activities and the resources needed to accomplish them.

Q: How many people are required in a team?

A: rather than a specific number of individuals, what is required are specific skillsets. For example, if the scientific analysts were capable of effectively conducting the R analysis, then a dedicated R analyst would not be required. In current assessments, teams range between 2 and 8 people.

Q: How long does it take to calculate OHI at a regional scale?

A: This depends on many things: budget and number of people involved, the scale of the study area and whether new regions will need to be created, how easily data can be acquired, how much local data can be incorporated, how many goal models need to be changed. Additionally, decisions about setting reference points require input from experts.

Q: How much time will modifications by an R analyst take?

A: This will depend on if you are changing any models, and potentially data layers–but a lot of changing data layers just requires registering them properly in `layers.csv` (and maybe `pressures_matrix.csv` and resilience_matrix.csv if they are pressures or resilience files) and having the `functions.R` file call those layers. That is more 'bookkeeping' than actual R programming.

Q: How much time will modifications by a GIS analyst take?

A: this will depend on how many layers you are processing: you are clipping spatial data? That will take some time because there are quite a few files, but maybe not too long since it is pretty small scale and once there is a clipping mask created I think you apply it to other files.

Q: Which goals require a GIS analyst?

A: All goals using spatial data could potentially require a GIS analyst. These goals are commonly: habitat-based goals and sub-goals: (Coastal Protection, Carbon Storage, Habitats—a sub-goal of Biodiversity), Food Provision, Sense of Place, Species—a sub-goal of Biodiversity, Clean Waters

8.4 Structure

Q: Can we remove or add goals to the OHI?

A: A lot of deliberation went into defining the ten goals, and they seem to do a pretty good job of covering many if not most ocean uses, so additional goals may not be necessary. But it could be that they eclipse or replace an existing goal.

8.5 Reference points

Q: Can planning targets can be used as the reference points?

A: Yes, planning targets can be used as reference points. This won't be appropriate for every goal, but there are cases where this seemed best (example: iconic species sub-goal in the global assessment, mariculture sub-goal in the US West Coast assessment).

Q: What is sector evenness?

A: Sector evenness (also called a diversity index) is an economic concept that is included in OHI to enable comparison across many different sectors included in the Livelihoods & Economies goal. This goal evaluates jobs, wages and revenues for nine marine employment sectors. The distribution of employment across these nine sectors is an effective indicator of resilience. If total employment within a community is primarily based in one or two sectors, the overall economic system will be excessively vulnerable to downturns in those sectors. Conversely, if employment is spread relatively evenly throughout all nine sectors, the overall system will be more robust and resistant to such disturbances. Overall revenue within the community will remain more stable during such downturns, and workers displaced by a downturn in their sector may be able to find employment in another sector without leaving the community.

8.6 Appropriate data layers

Q: Shipping and port activity are hardly affected by the health of the ecosystem. Why are these included in the Index?

A: Shipping and port activity are included as pressures only

Q: Can oil spills be included in OHI?

A: Yes, oil spills could be included as a pressure and in the Clean Waters goal.

Q: Is seasonal (non-permanent) sea ice included in OHI habitats?

A: No, sea ice only includes permanent sea ice.

Q: Can seaweeds be included in the Carbon Storage goal?

A: Because they store carbon for less than 100 years, seaweeds and corals are not included in the carbon storage goal. While the pelagic oceanic carbon sink (phytoplankton) plays a large role in the sequestration of anthropogenic carbon, the pelagic ocean mechanisms are not amenable to local or regional management intervention. Phytoplankton and contribute to carbon fixation when they die and sink to the sea bottom at sufficient depth, because it is effectively out of circulation. However, if those phytoplankton are eaten, the carbon is cycled back into the system and not sequestered. Something that could potentially be included in the carbon storage goal is mollusc shells, if they are added to a landfill and not recycled in the sea. So if information on mariculture production and waste disposal are available, this could be an interesting addition to carbon storage at a regional scale.

Q: Is coastal engineering included in Coastal Protection? What if it reduces erosion?

A: We did not include an assessment of the protection afforded by man-made structures, such as jetties and seawalls, because these structures cannot be preserved without maintenance, may have other negative side effects (e.g. alter sedimentation rates causing erosion in new locations), thus they do not constitute long-term sustainable services. Coastal engineering (jetties, harbours, marina and breakwater) is not natural, and is mostly seen as a pressure. It will also be evident in the status of due to decreased natural habitat. It gets tricky when structures are built to help reduce coastal erosion–they are still manmade and therefore not a natural benefit that the ocean provides. But if available data allow, it might be possible to include tradeoff effects: maybe in areas where natural habitats are degraded and man-made structures have been built to reduce erosion, we could reduce the pressure that would otherwise be applied.

Q: How is seawater used for cooling on-shore power plants incorporated into OHI?

A: The use of cooling water for on-shore power plants would be a pressure on the ocean, since it causes entrapment of fishes, larvae, etc, and usually is circulated back into the ocean at higher temperatures (and maybe other chemicals, minerals, etc). Since the energy is coming from land-based activities, there isn't a service that the ocean is providing that 'benefits' people, it is only a pressure from the OHI perspective.

Q: How is freshwater production through desalination incorporated into OHI?

A: Desal would be incorporated into OHI in several places. The benefit is that there is freshwater produced, which could be incorporated into the Natural Products goal (or potentially into its own goal). Data required would be the volume of freshwater created based on the volume of seawater involved and spatial extent. Setting the reference point would not be based on how much can be produced, but some other targets perhaps set by government (percentage of the population served). Similar to the mariculture sub-goal and tourism goals, any negative effects caused by desal that affect other goals (example: species) do not influence the ability to obtain desalination targets now and in the future. Therefore, the sustainability coefficient only measures the ability to sustain that goal, but not the impacts on other goals: instead, they are taken into account as pressures when calculating the other goals. Desal should be included as a pressure similar to cooling on-shore power plants since the discharge brine is dense, doesn't plume very well and there are chemicals involved.

8.7 Food Provision

Q: Could the culture of marine fish in closed pools on-shore be included in the Mariculture sub-goal?

A: This should not be included because onshore aquaculture does not require a marine environment.

Q: Can aquaculture farms that receive seawater supply and return seawater back to the sea be included in the food provision goal?

A: This would be more appropriately included in the Mariculture sub-goal, and with finer-scale data additional pressures due to the intake pipes and the processed brine back into the marine system could be incorporated as well. Natural Products

Q: If natural products are all produced through on-land aquaculture, should this goal be removed?

A: In this case you would probably have good reason to exclude the natural product goal due if this was defendable through discussions with experts and any reports/papers on the topic. This would also depend on the origin of these natural products–are they from the region's waters? Habitat-based goals

**Q: I have fish that are used as feed for other fish (e.g., sprat) in my country. Can I include them in this goal?

A: It would be more appropriate to include them in Natural Products rather than Food Provision. This is because they are not being consumed directly. Fish such as sprat, for example, may be used to feed pigs in addition to other fish, and therefore you would need to know how much (tonnage) is being produced, and where it is going to be able to accurately distinguish these categories to avoid double-counting.

(Source: OHI Baltic Workshop, February 2015)

Q: How is coral health calculated?

A: Coral health was estimated by compiling point data from multiple studies of percent live coral cover. In other words, estimates of coral cover within transects of certain sites were repeated in time and we used that rate of change in time as an indication of health of the reefs in the whole region. The difficulty lies in 1) having enough different locations sampled that you can say something about the whole region and 2) finding studies that did repeated measures in time, in the same location, over at least 20 years. In the Global 2013 assessment, there were so few datasets that satisfied this condition that we had to pool observations from different locations.

Q: Is it possible to calculate habitat goals when there is only one year of habitat data?

A: With only one year of habitat data, it is not possible to calculate the trend (which requires 5 years of data). Instead, it might be best to use the available habitat data to calculate the current status and then to overlay pressures for the last 5 years to calculate trend.

8.8 Livelihoods & Economies

Q: Benefits gained from Wild-caught fisheries, Mariculture, Tourism & Recreation are included in specific goals. Why are these counted again in Livelihoods & Economies?

A: The quantity of fish, mariculature, and participation in T&R are considered separately in goals whereas the monetary component is captured in L&E.

Q: Why are revenue data from shipping, boat building, ports and harbors included as revenue? Do these activities rely on a healthy ocean?

A: These sectors are included in the Ocean Health Index because the demand for some of those boats (fishing boats, sailboats, yachts) is dependent on a healthy ocean.

Q: Why isn't oil and gas industries included in revenue?

A: The Natural Products goal does not include non-living items such as oil, gas, and mining products, because these practices are not considered to be sustainable. They are also done at such large scales that including them would essentially make OHI an index for oil and mining–and they are not truly an ocean product. Because these products are not included in terms of quantity extracted, it did not seem appropriate to include information regarding jobs, wages or revenue.

8.9 Tourism & Recreation

Q: How do I calculate the sustainability term for TR?

A: The best way is to use a local indicator or measure of tourism sustainability or competitiveness, otherwise use the TTCI value from the Global 2013 assessment for the study area (applied evenly across all regions.

8.10 Natural Products

Q: Where do Natural Products come from?

A: In the global assessments, Natural Products data come from the UN's Food and Agriculture Administration (www.fao.org/fishery/statistics/software/fishstatj/en). These data are compiled and reported by product for each country, and available by downloading the FishStatJ software.

8.11 Species

Q: Can species and iconic species model scores be penalized if there are local flagship species that have not been evaluated?

Global data are based on IUCN assessments. For these evaluations, IUCN chooses a taxon (e.g. sharks) and a group of world experts assess it comprehensively. Locally identified species identified in a regional assessment may not be in the IUCN database because they do not belong to one of the taxa that have been selected for assessment, or because the experts that did the assessment did not know that information existed. In either case, there is no connection between what IUCN reports and what assessments are done locally. Therefore, it might not be fair to penalize a study area for missing species. For biodiversity, it is unrealistic to expect that all species are assessed, so it seems unfair to penalize for unassessed species. In the fisheries goal, there are penalties for species that are exploited but not assessed, because if there are landings data, it means they are somewhat measurable, and so it is reasonable to expect they should be at least monitored.

It might be reasonable to penalize unassessed iconic species. It is a smaller list of species that are specifically identified as being of interest, for one reason or other. This would work for species that have some form of assessment - unless that information already exists, it might be unrealistic to try to produce the data layer required to develop a new model.

8.12 Sense of Place

Q: Data are only available for marine protected areas, not terrestrial protected areas. Can we still calculate the Lasting Special Places sub-goal?

A: Yes, it is possible to calculate only the marine component of this sub-goal: this is not ideal but OHI is flexible to work with the data available.

Q: Should we calculate each category used in our assessment (e.g., antiquities, MPAs, beaches of special interest) independently, and then give the same weight (e.g., a third of the goal score) to the three categories, or should we instead pool the actual areas of the 3 categories?

A: Whether you group them together or calculate each category separately depends on reference points. Maybe you want 10% of offshore water to be in MPAs, but only 5% of coastlines to be beaches and 3% Antiquities, for example; in this case, you would calculate them separately and then add them together. But if you want 10% of your country's coast to have any combination of these things, you would keep them together.

(Source: OHI Israel assessment discussions, 2014-2015)

8.13 Pressures

Q: How are single ecological pressures (si in Equation S8) calculated?

A: Data included in pressures calculations are accessed in the same manner as any other data layer, and rescaled from 0-1 with an appropriate reference point. For further information, see HowTo_GatherAppropriateData and HowTo_CalculatePressures from ohi-science.org.

Q: Does the pressures matrix need to be changed?

A: It is likely that the pressures matrix will not need to be changed. The weights assigned in the matrix were set using information from the literature and by experts; the matrix was created by Halpern et al. 2012.

Q: How is commercial high and low bycatch calculated?

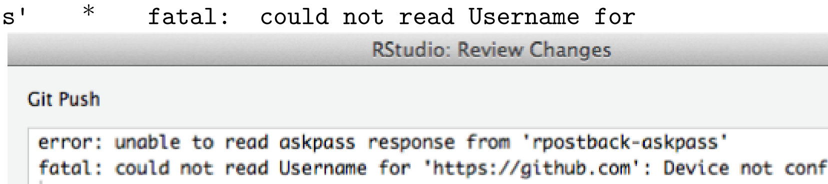
A: Commercial high and low bycatch are categorical values that were set based on fishing gear type. This began as a list of gear types used, producing a range of potential bycatch frequencies (from local reports when possible), which can be rescaled.

9 Toolbox Troubleshooting

The Toolbox prints messages during its processing to help guide error checking and debugging. Here are a few troubleshooting tips. This section will be updated frequently; please share any problems that you encounter.

9.1 Error: RStudio won't push to GitHub

When pushing committed changes within RStudio, would return the error * `error: unable to read askpass response from 'rpostback-askpass'` * `fatal: could not read Username for 'https://github.com': Device not configured`



Here's how we fixed it: we updated `git.exe` to the latest version, 2.2.1, edited the search path to point to the new version, made sure the *git* credential.helper was configured to be able to access the OS X keychain, and pushed a test commit from terminal to store the username and password in the keychain, where it can be accessed from other apps like RStudio. Easy peasy!

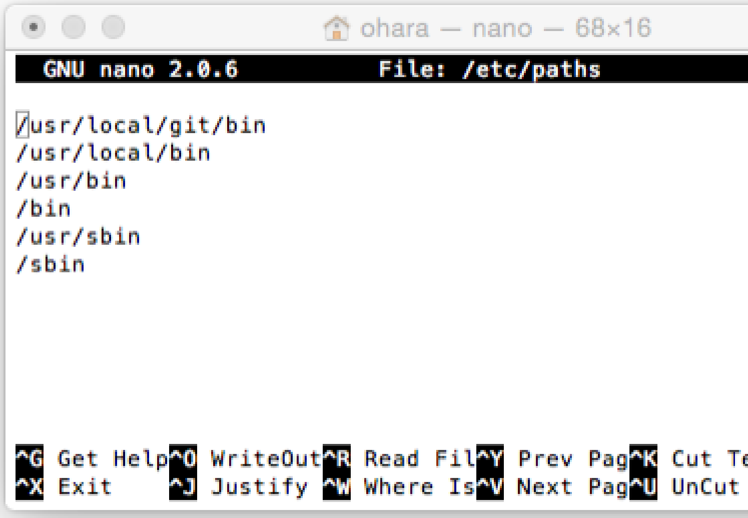
1. To check your current version of `git.exe`, type this at the terminal command line:
   - `$ git --version` should return something like:
   - `git version 2.2.1` (this is what you'd like to see)
2. To update, go to http://git-scm.com/download/mac, download the latest *git* for OS X, install it.

3. In terminal, type `git --version` and verify that it reports the new version. If it shows the new version, great! Skip to Step 5.

    - Don't be sad if it doesn't! If you still see the old version, the installer put the new version into a different directory, which has a lower priority in the search path, so now to update the search path. The default Apple *git* seems to install the `git.exe` into `/usr/bin/` directory, this particular updater seems to install into `/usr/local/git/bin/` directory. The search path needs to be updated to look for `git.exe` in the new directory first.

4. To change the search path, open up the paths file in `nano` editor using `sudo`:

    - `$ sudo nano /etc/paths`
    - At the top line of the paths file, add the directory for the updated *git*: `'/usr/local/git/bin'`(without



the quotes) so it looks like the top line here:
    - Then hit `control-X` to exit, then `Y` in response to the save prompt.

5. Make sure your `git config` is up to date, including `credential.helper`:

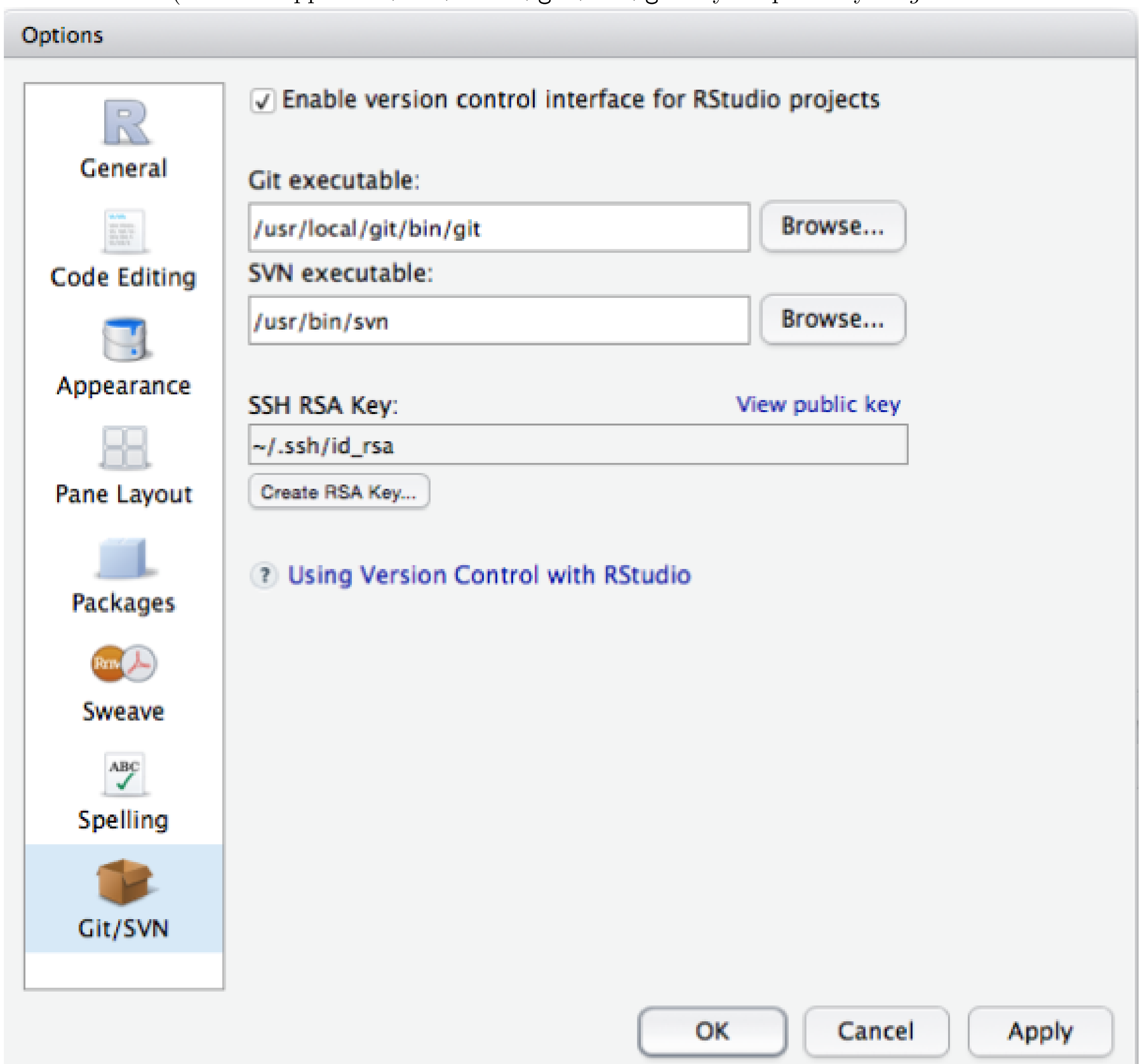
    - `$ git config --global -l` should return something like:
    - `user.name="Casey O'Hara"`
    - `user.email=ohara@nceas.ucsb.edu`
        – see https://github.com/OHI-Science/ohiprep/wiki/Setup#git_identity for help on updating user.name and user.email
    - `credential.helper=osxkeychain`
        – (if you need to configure the credential helper: https://help.github.com/articles/caching-your-github-password-in-git/)

6. Now while you are in Terminal, go ahead and clone a repository to your computer and push a test commit. Once you are prompted for your username and password, your info will get stored in the keychain:

    - Steps (borrowed from these instructions): https://github.com/OHI-Science/ohiprep/wiki/Setup#git_identity
    - Change your working directory: `cd github`
    - Clone into a repository with a URL *for which you have permissions*, e.g: `git clone https://github.com/omalik/zaf.git`

- Change directory to that repository: `cd zaf`
- Check status: `git status`
- Push a test commit to that repository: `touch test.md` -> `git add test.md` -> `git commit -m "testing"` -> `git status` -> `git push`
- Check status again: `git status`

7. Now that *git* is updated and your username and password are set, make sure RStudio knows the location of the new `git.exe`. In RStudio, select **Tools > Global Options...**, select the `Git/SVN`, and browse to the new `Git executable` (it should appear as `/usr/local/git/bin/git` if you updated your *git* version as above).



Next time you push a commit from RStudio, it should remember the username and password from your test commit in Step 6, and you should be good to go.

9.2 Loading RWorkspace on Restart

When you restart your R Session (**Session > Restart R** on a Mac), if you see that it is trying to load `ohicore`, it may give you an error:

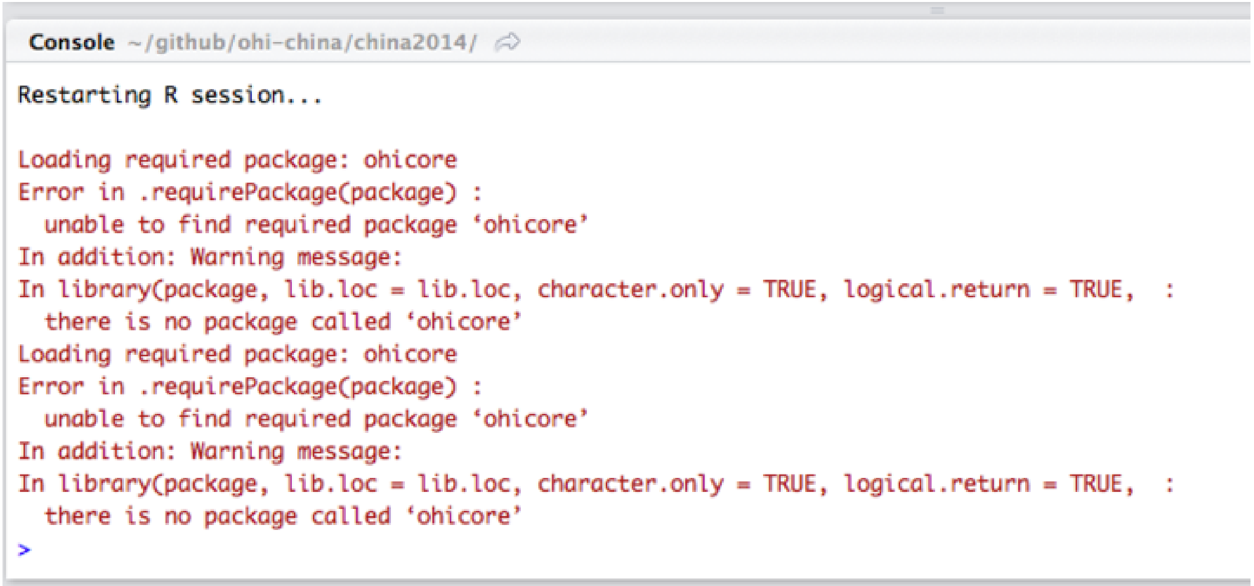


Figure 54:

You do not want it to load `ohicore` or to save anything in your workspace. You will need to change the default setting from you **.Rproj** file. Steps to do this:

1. Go to Project Options, either in the pull-down menu or by double-clicking the .Rproj file:

2. Change all options to **No:**

9.3 Calculating Pressures. . .

9.3.1 'The following components for [goal] are not in the aggregation layer [layer]. . . '

Example:

This error means you should update your pressures matrix because it expects there to be components that your region does not have.

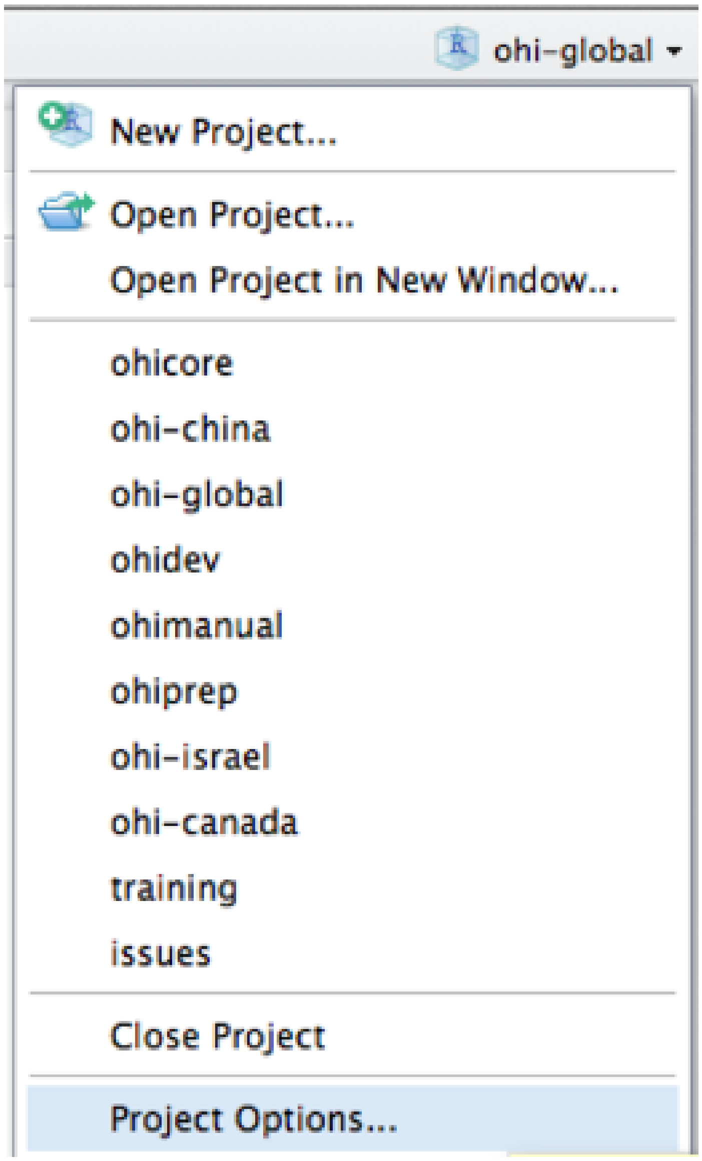

ohi-global
New Project...
Open Project...
Open Project in New Window...
ohicore
ohi-china
ohi-global
ohidev
ohimanual
ohiprep
ohi-israel
ohi-canada
training
issues
Close Project
Project Options...

Figure 55:

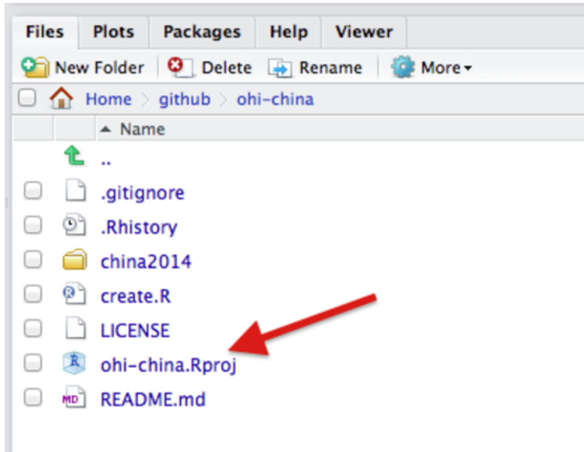
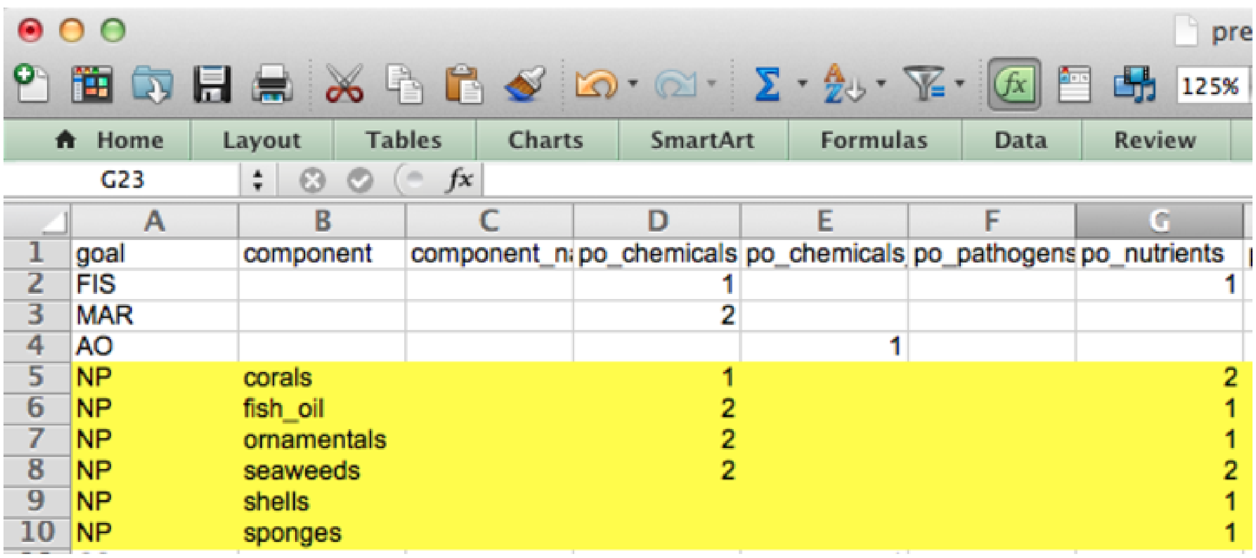


Figure 56:

9.3.2 'Error in matrix. . . '

Example: >



	A	B	C	D	E	F	G
1	goal	component	component_n	po_chemicals	po_chemicals	po_pathogens	po_nutrients
2	FIS			1			1
3	MAR			2			
4	AO				1		
5	NP	corals		1			2
6	NP	fish_oil		2			1
7	NP	ornamentals		2			1
8	NP	seaweeds		2			2
9	NP	shells					1
10	NP	sponges					1

This error means there is an empty column in `pressures_matrix.csv`, and the Toolbox cannot handle empty columns.

9.4 Calculating Resilience . . .

9.4.1 'Error in match(x, table, nomatch = OL) : object id_num not found'

This error means you should check that there is at least one entry for each goal (for each row) in `resilience_matrix.csv`.

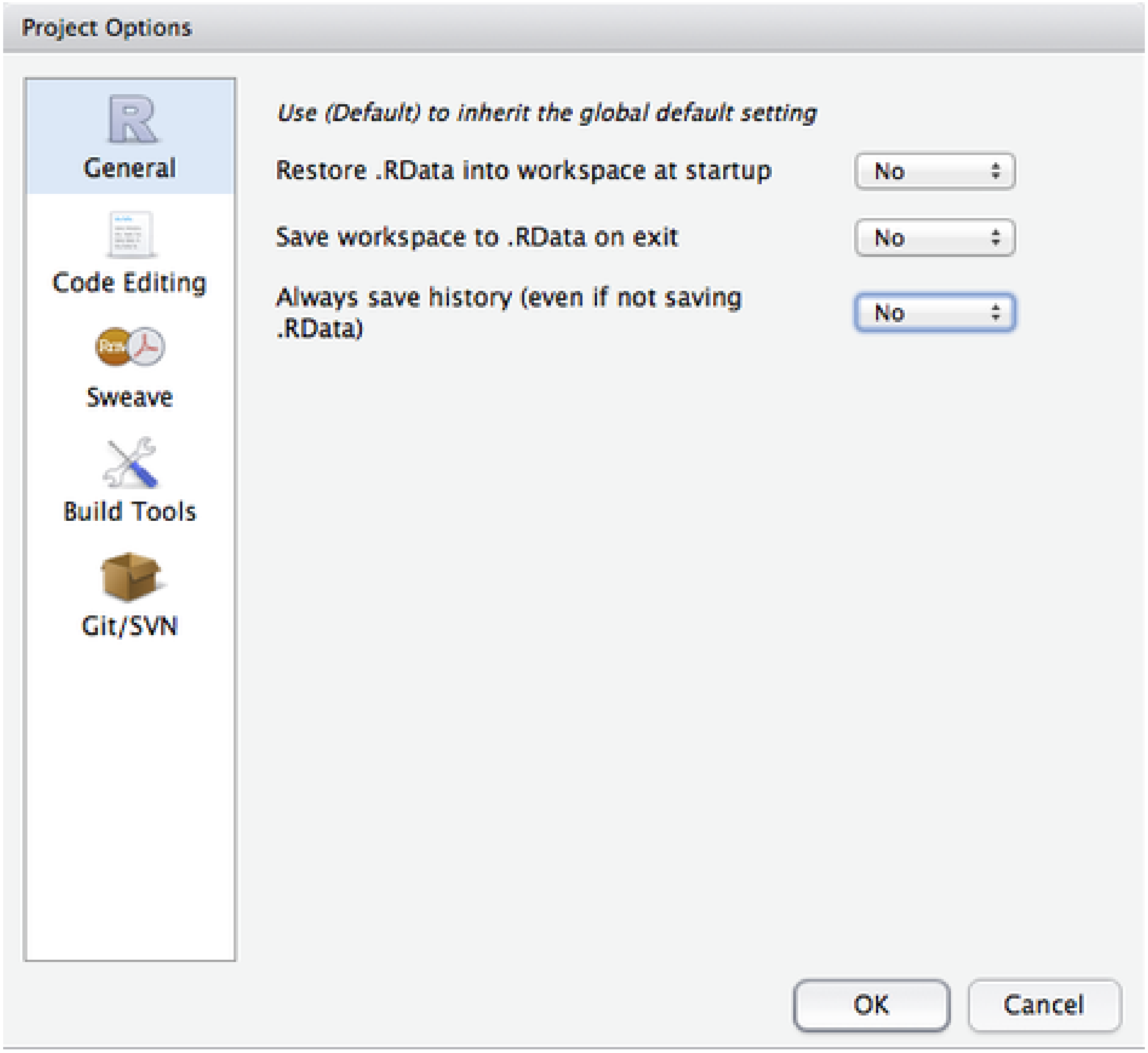


Figure 57:

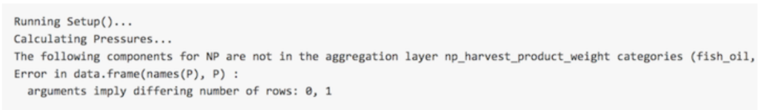
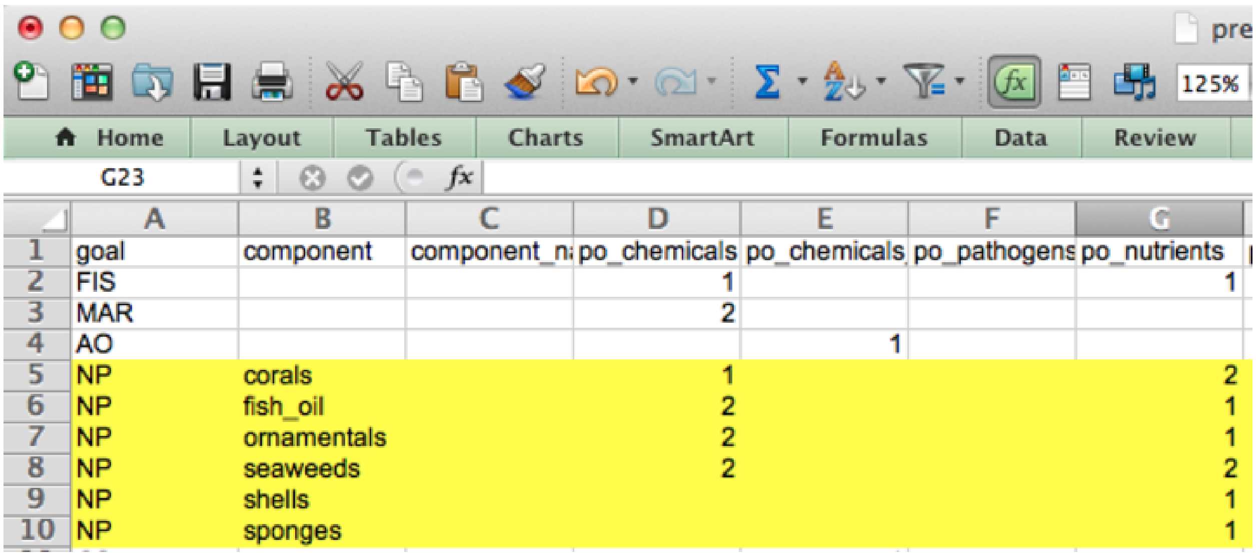


Figure 58:



	goal	component	component_n	po_chemicals	po_chemicals	po_pathogens	po_nutrients
1	goal	component	component_n	po_chemicals	po_chemicals	po_pathogens	po_nutrients
2	FIS			1			1
3	MAR			2			
4	AO				1		
5	NP	corals		1			2
6	NP	fish_oil		2			1
7	NP	ornamentals		2			1
8	NP	seaweeds		2			2
9	NP	shells					1
10	NP	sponges					1

Figure 59:

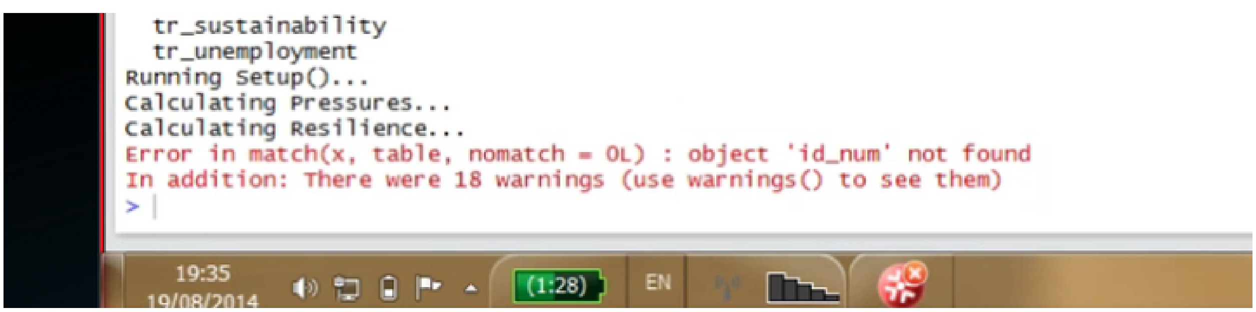


Figure 60: