The Ocean Health Index Toolbox 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 annual global assessments to track changes in global ocean health. At the same time, we have been developing the **Ocean Health Index Toolbox** software that will enable others to conduct assessments on their own using the OHI framework. Here, the **Ocean Health Index Manual** describes how to use the Toolbox software.

OHI scores by goal are calculated at the scale of the reporting unit, which is called a **region** and then combined using a weighted average to produce the score for the overall area assessed, called a **study area**.

1.2 The Ocean Health Index Toolbox

The Ocean Helath Index Toolbox Application (App) is open-source software developed to facilitate Index calculations at any scale. The Toolbox App runs using the statistical programming language R and displays input data and calculated scores graphically with maps, histograms, and tables. Goal scores are calculated for each region separately and then combined using a weighted average to produce the score for the overall study area assessed. Modifications can be made to the global studies, allowing calculation of scores with updated data that can then be visualized with the Toolbox App.

The Toolbox can also be used to calculate scores in smaller-scale **regional assessments** after finer-scale data has been gathered and decisions have been made regarding goal models, pressures and resilience, and reference points. The Toolbox App therefore enables the Ocean Health Index framework to be customized to an area of interest, incorporating the data, indicators, and priorities regarding ocean-derived benefits that are relevant to the chosen area. The App 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.

We recommend first becoming familiar with the Toolbox App and exploring the results from the global assessment before beginning a regional assessment.

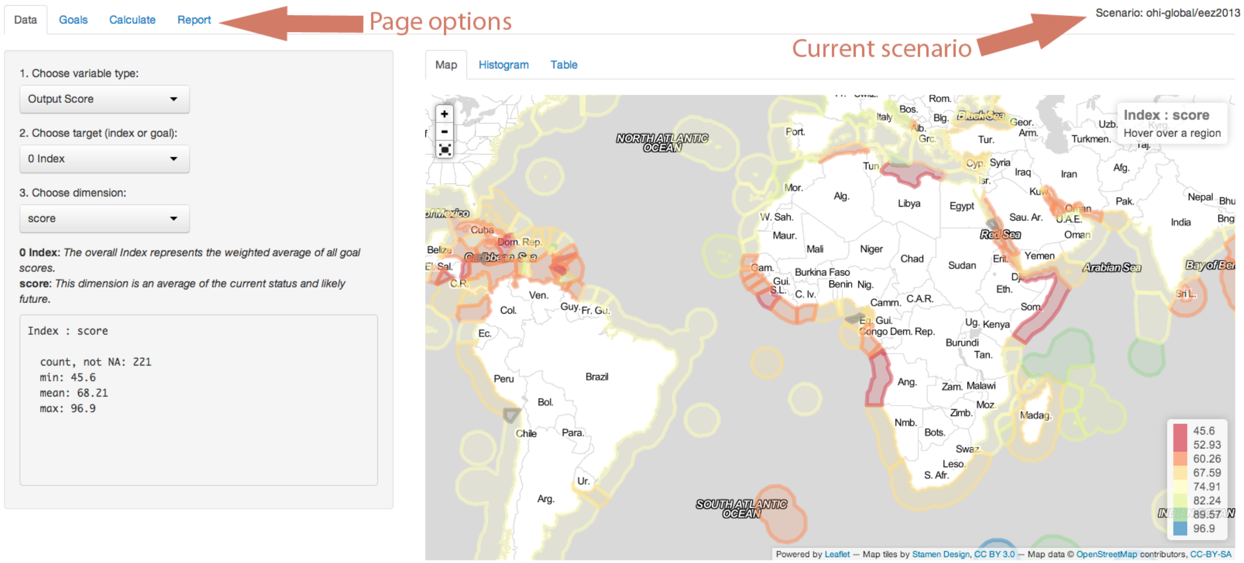
Requirements: an Internet connection for the initial Toolbox App installation. The Toolbox runs on both a Mac and PC.

1. Install the latest version of R (http://cran.r-project.org/).
2. Launch the Toolbox Application (http://ohi-science.org/pages/install.html).

2 Overview of the OHI Toolbox App

The Toolbox Application (App) runs through a web browser and has three **Page options**: *Data*, *Calculate*, and *Report*. The *Data* page provides several ways of viewing the data (*Map*, *Histogram*, *Table*), and is the default home-screen when the Toolbox is opened. The *Calculate* page is used to calculate goal scores based on the information in the file system (data can be changed and tested). The *Report* page provides different methods of reporting the data.

The **Current scenario** is displayed in the upper-right corner of the Data page. This identifies the scale (example: global) and year (example: 2013) of the information displayed.

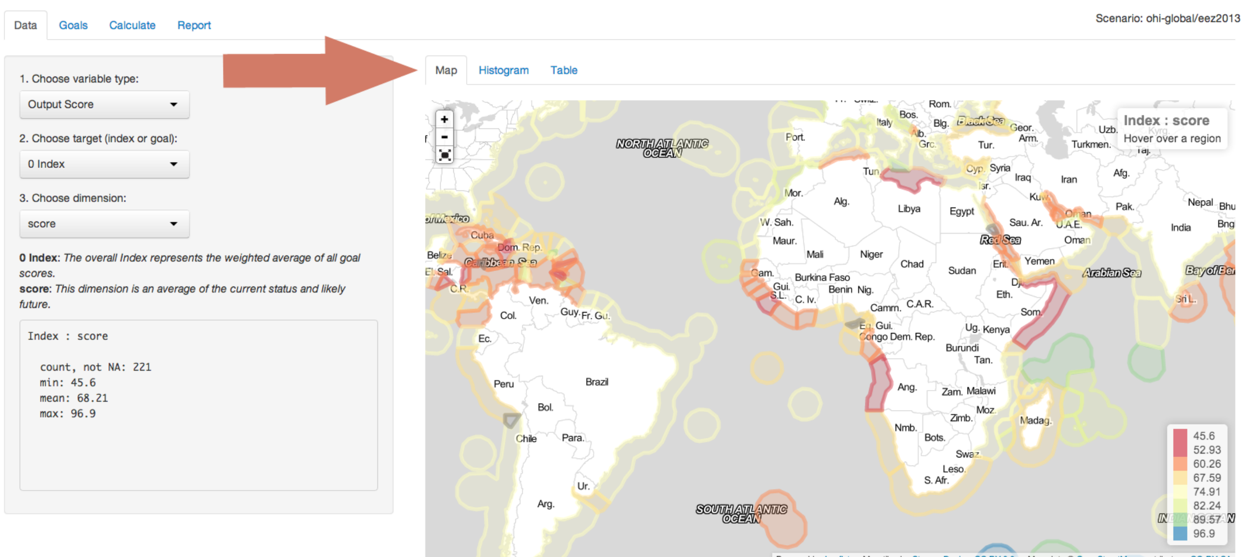


2.1 Data page

2.1.1 Overview of display options

The Data page displays input data or calculated scores for each goal parameter, and presents the information as a Map, Histogram, or Table. These options are presented as tabs located above the map (Map view is the default display option for the Data page).

Data displayed in Map form:



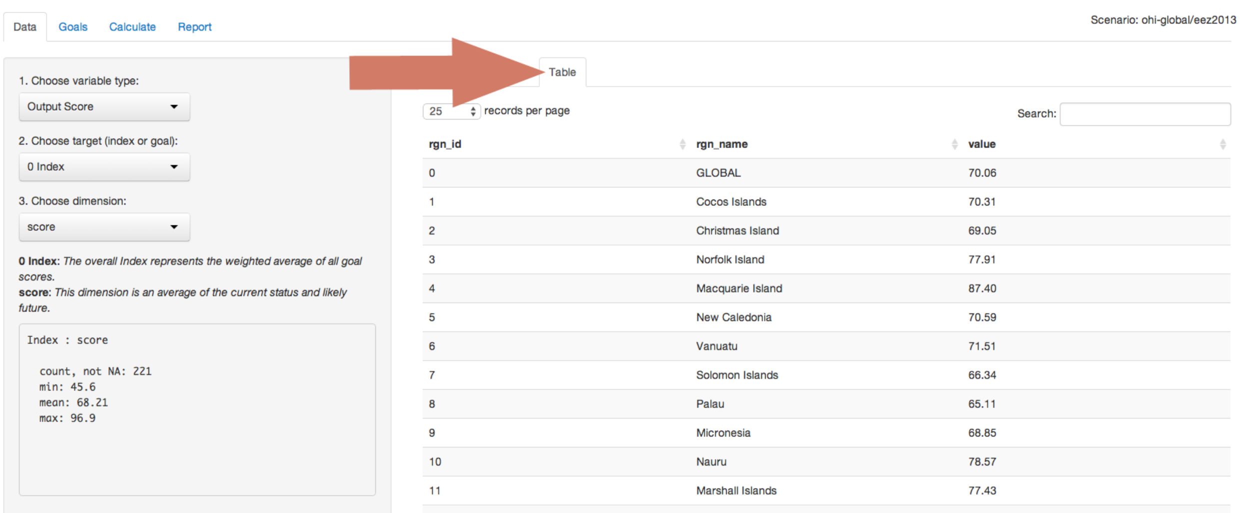
The map displays data for every region as reported in the scenario. Zooming in and out is possible with the plus/minus in the upper left of the map, and a color legend is displayed in the lower right corner of the map. The legend provides a linear colormap of the data and the range of values will change as different variables are selected.

The target and dimension chosen from the drop-down menu is also displayed as text on the top right corner of the map. Below this information, the region name, (region number), and value appear if the user's mouse hovers over a specific region. When the value of that region is displayed, the region will darken on the map. If the mouse is not indicating a specific region, this area will instruct to 'hover over a region'.

Data displayed in Histogram form:

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).

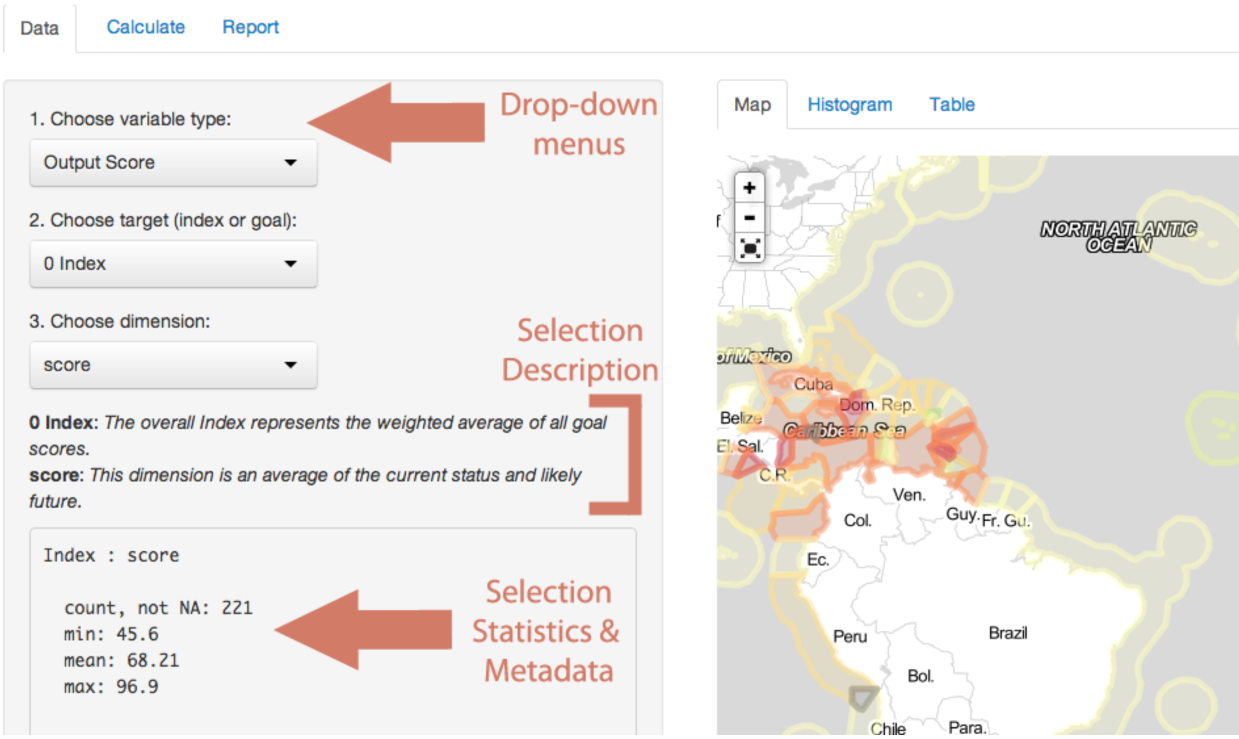
Data displayed in Table form:



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. It is possible to search the data using the search bar at the upper right of the table (caps-sensitive). It is also possible to search within individual columns by entering the search term at the bottom of each column; this option is more easily displayed by changing the number of records per page to 10 using the drop-down menu. Data may also be sorted the arrows at the left of each column name. Sorting by rgn_id is the default.

2.1.2 Overview of variable options

The Data page has drop-down menus from which the user chooses the data to be displayed by the Toolbox. The data selected from the pull-down menus can be viewed in Map, Histogram, or Table form as described in the 'Overview of display options' section above. Descriptions, statistics and metadata for the chosen fields are also displayed below the drop-down menus on the left side of the page.



The first selection to be made from the drop-down menus is variable type, in which the user 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.

For example, if the user selects 'Output Score' as the variable type (which is the default), they will then be able to choose a goal/sub-goal (target), and the score calculation (dimension) to be reported.

On the other hand, if the user selects "Input Layer" as the variable type, they will be able to choose a target and a specific data layer that is associated with that target. If that layer has multiple categories or years available, the user will be able to select a preference, with a default being the first category alphabetically and the most recent year.

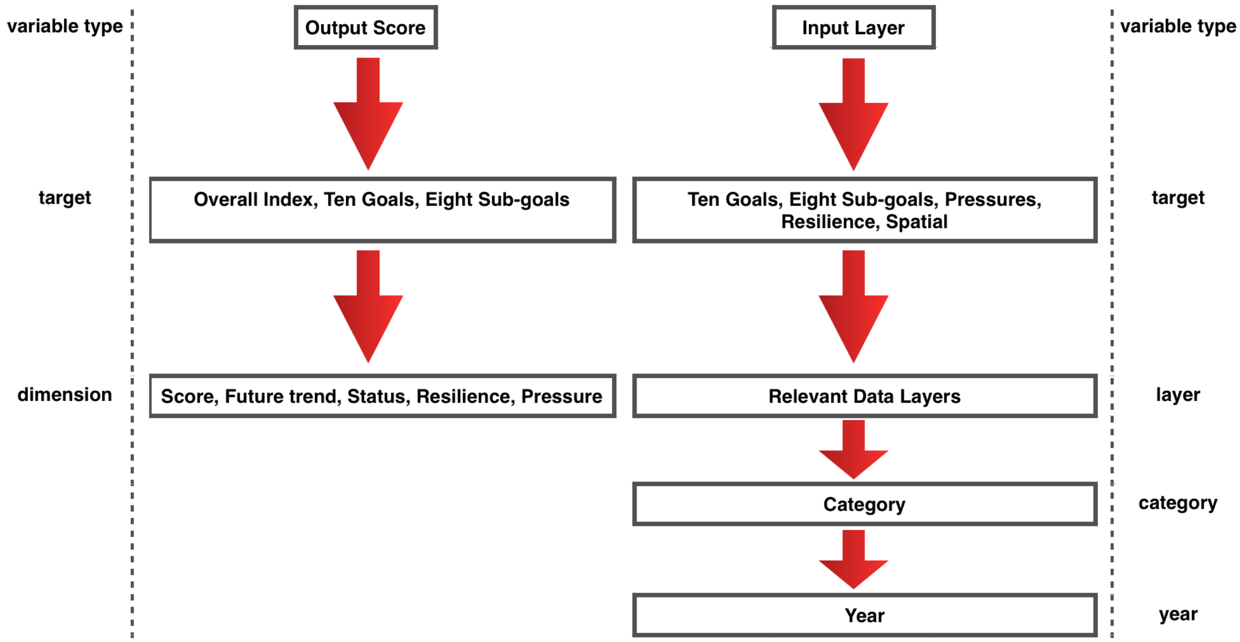
2.2 Calculate page

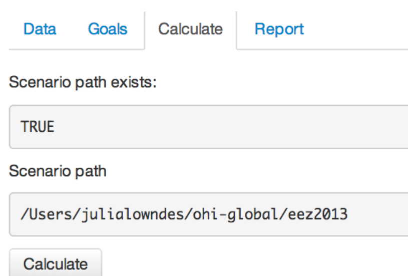
The Calculate page is used to calculate the Index. The Calculate page displays the "Scenario path" in the user's home directory where the folders are located.

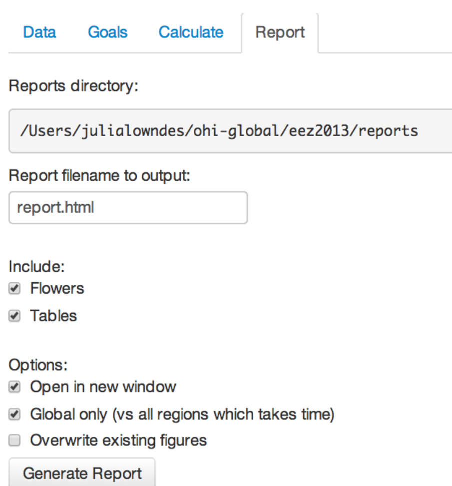
2.3 Report page

The Report page allows the user to create a report of results as .html and .pdfs files.

It is currently possible to create flower plots and tables with several options, including saving global figures or figures per country. In future versions of the Toolbox App, more options for visualizations, including maps, histograms, and equations, will be possible. It will also be possible to compare different scenarios.


variable type
Output Score
Input Layer
variable type
target
Overall Index, Ten Goals, Eight Sub-goals
Ten Goals, Eight Sub-goals, Pressures, Resilience, Spatial
target
dimension
Score, Future trend, Status, Resilience, Pressure
Relevant Data Layers
layer
Category
category
Year
year


Data
Goals
Calculate
Report
Scenario path exists:
TRUE
Scenario path
/Users/julialowndes/ohi-global/eez2013
Calculate

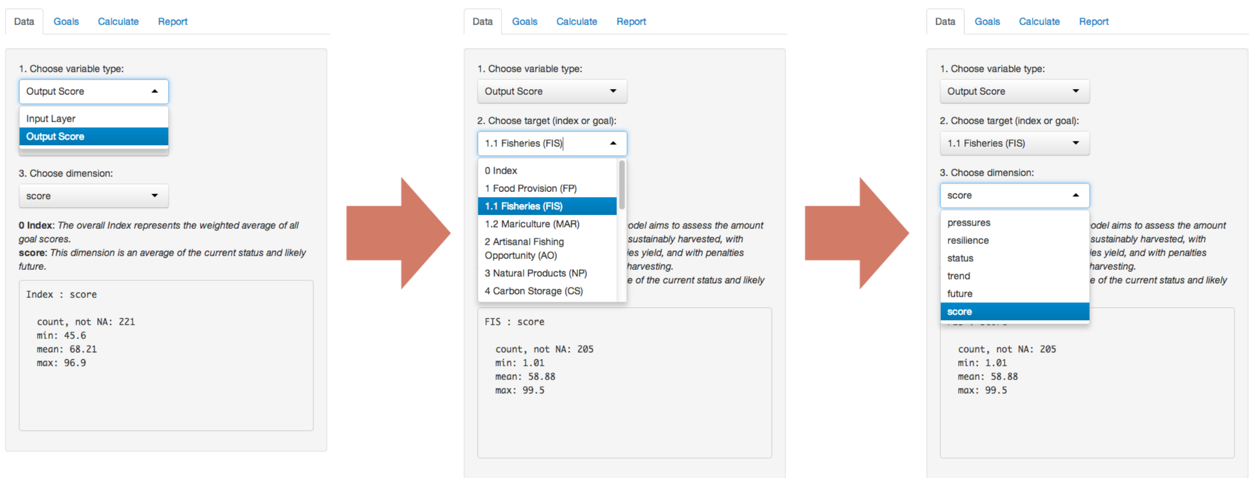

Data
Goals
Calculate
Report
Reports directory:
/Users/julialowndes/ohi-global/eez2013/reports
Report filename to output:
report.html
Include:
Flowers
Tables
Options:
Open in new window
Global only (vs all regions which takes time)
Overwrite existing figures
Generate Report

3 Explore Global Results with the Toolbox App

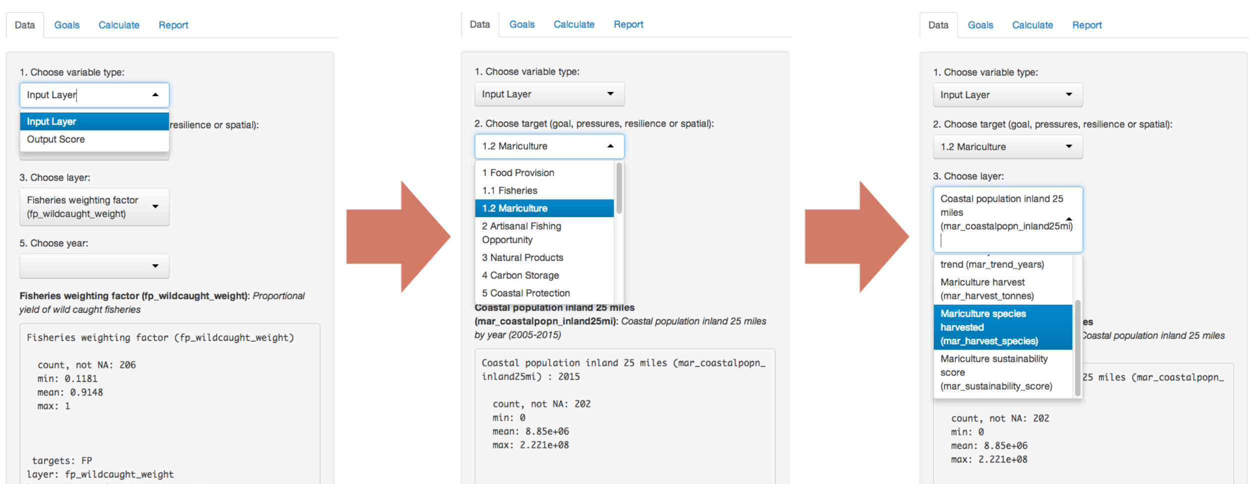
3.1 develop

For example:

Output Score > Fisheries (FIS) > score shows the final calculated score for the fisheries sub-goal in the current scenario (2013).



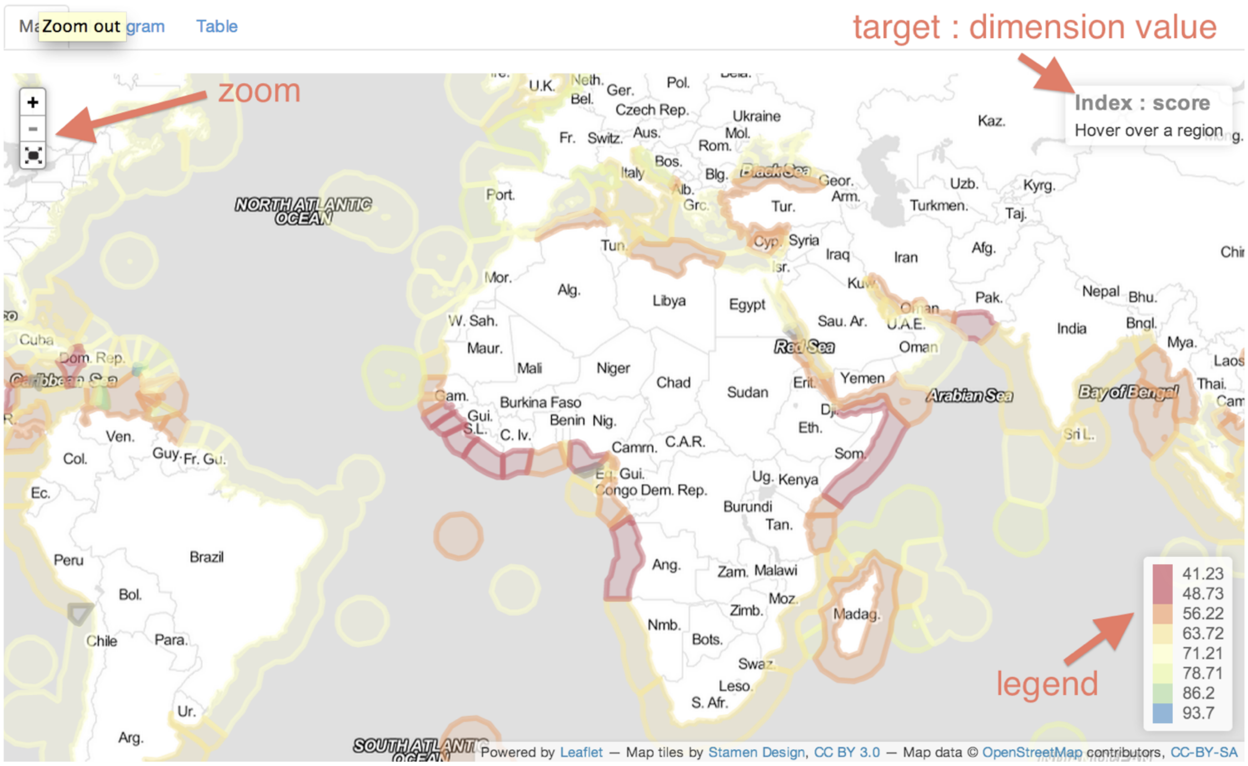
Input Layer > Mariculture > Mariculture species harvested shows the different harvested species that were used to calculate the mariculture sub-goal in the current scenario (2013).

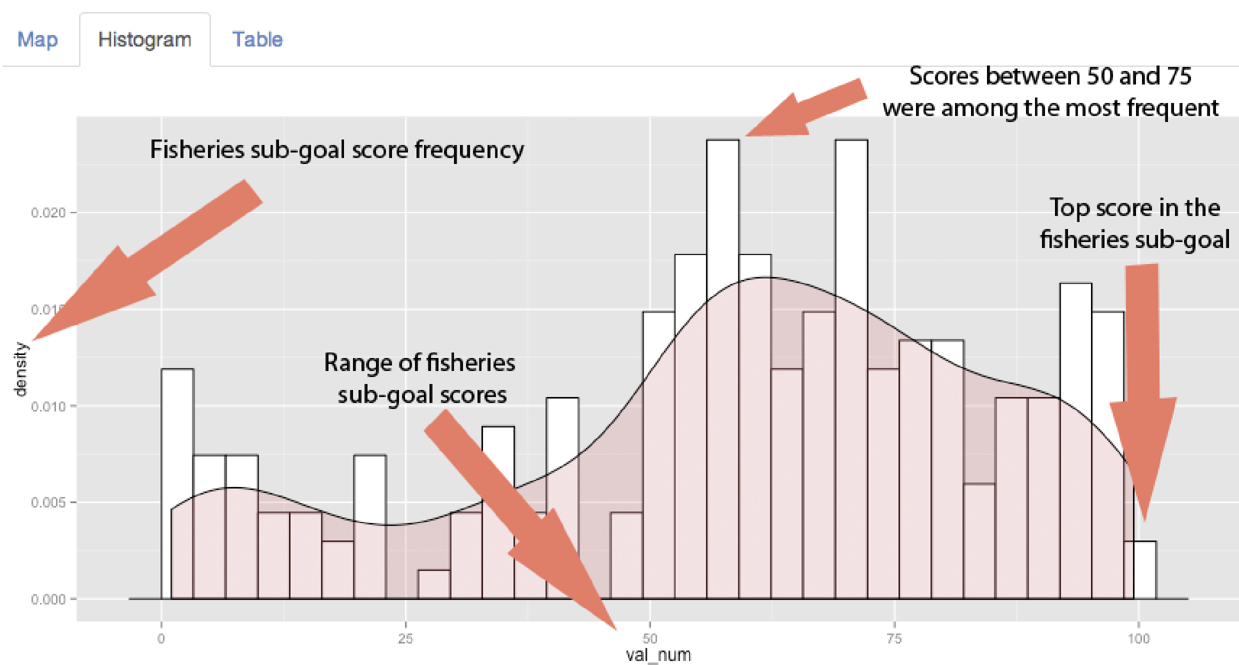


3.1.1 Map

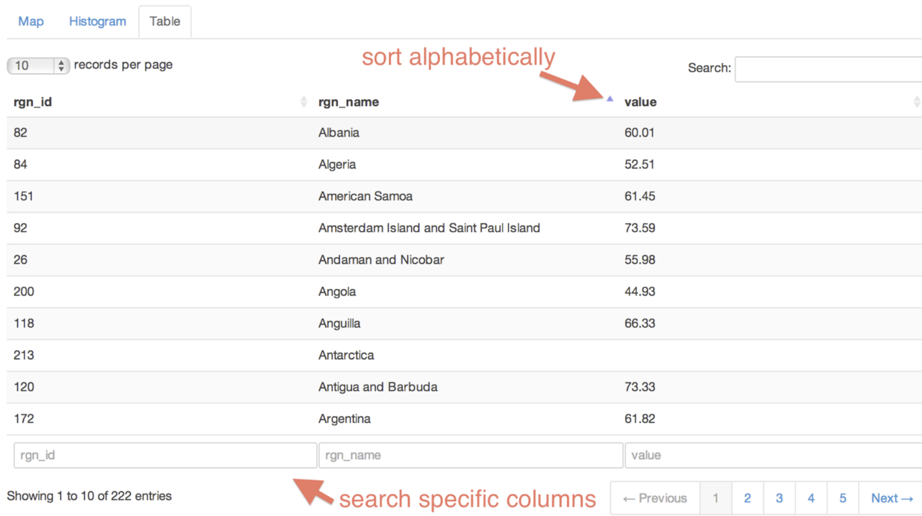
3.1.2 Histogram

For example, if the **Output Score > Fisheries > score** sub-goal is selected, the information displayed by the histogram is as follows:


Map
Zoom out
Histogram
Table
target : dimension value
zoom
Index : score
Hover over a region
41.23
48.73
56.22
63.72
71.21
78.71
86.2
93.7
legend
Powered by Leaflet — Map tiles by Stamen Design, CC BY 3.0 — Map data © OpenStreetMap contributors, CC-BY-SA


Map
Histogram
Table
Scores between 50 and 75
were among the most frequent
Fisheries sub-goal score frequency
Top score in the
fisheries sub-goal
Range of fisheries
sub-goal scores
density
0.020
0.010
0.005
0.000
0
25
50
75
100
val_num

3.1.3 Table



rgn_id	rgn_name	value
82	Albania	60.01
84	Algeria	52.51
151	American Samoa	61.45
92	Amsterdam Island and Saint Paul Island	73.59
26	Andaman and Nicobar	55.98
200	Angola	44.93
118	Anguilla	66.33
213	Antarctica	
120	Antigua and Barbuda	73.33
172	Argentina	61.82
rgn_id	rgn_name	value

4 Introduction to OHI Regional Assessments

Regional assessments use the Ocean Health Index framework to study smaller spatial scales, often where policy and management decisions are made. Using ten criteria (goals), the Index scores how well coastal regions optimize their potential ocean benefits and services in a sustainable way relative to self-established reference points (targets), on a scale of 0 to 100. Regional assessments incorporate local priorities, higher-resolution data and indicators, and use tailored goal models and reference points, which produce scores better reflecting local realities. The OHI is designed to combine existing work into a comprehensive assessment of ocean health. And because the assessments are developed at the scale of decision-making using local data and parameters, the findings can help inform decision-making and management actions aimed at maximizing sustainable productivity while preserving vital natural capital.

Scores by goal are calculated weighted average to produce the score for the overall area assessed, called a **study area**. In regional assessments, coastal states or provinces are often the **regions** within a country, which is the **study area**.

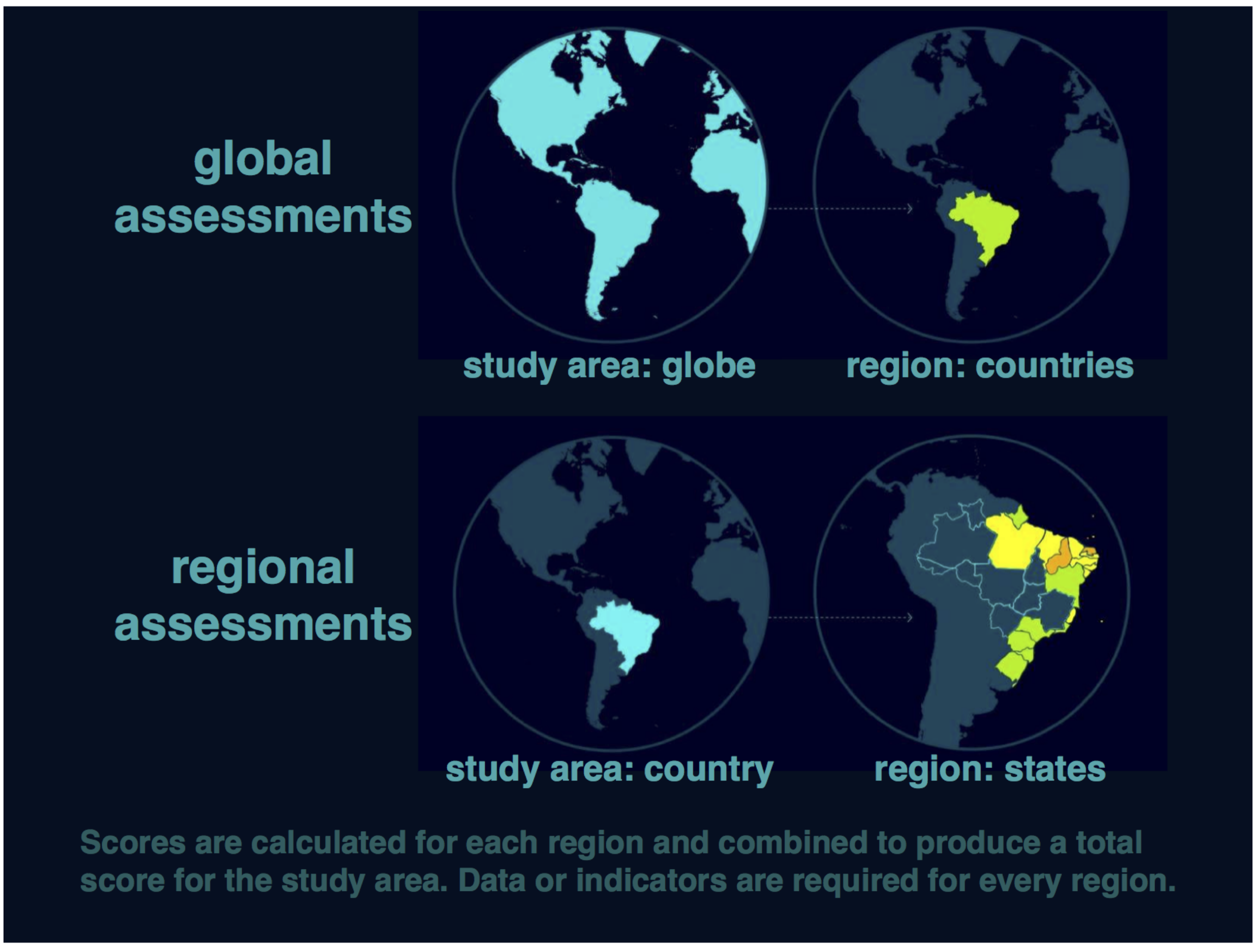
The Ocean Health Index framework is flexible to accommodate regional priorities: goal models should be modified to incorporate the best available local data and indicators, or excluded entirely to best represent regional attributes. Similarly, pressures and resilience measures can be refined using local data and indicators. Calculated Index scores are only as 'good' as the data on which they are based, so finding the best data or indicators available is fundamental.

The process for developing a regional assessment can be as valuable as the final calculated scores, since it creates an ocean alliance that combines knowledge and cultural values from many different perspectives and disciplines. Calculating Ocean Health Index scores at regional scales 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.

Regional assessments have been published in peer-review journals for the U.S. West Coast (Halpern et al. 2014) and for Brazil (Elfes et al. 2014), and more are underway.

4.1 Before getting started

Before beginning a regional assessment, it is important to have planned several things:


global assessments
study area: globe
region: countries
regional assessments
study area: country
region: states
Scores are calculated for each region and combined to produce a total score for the study area. Data or indicators are required for every region.

- Develop strategic plan and timeline
  - determine resources available
  - outline timeline with any meetings and workshops necessary
  - engage management early for results to be most useful (optional)
- Assemble a qualified team with diverse skills
  - have a broad scientific understanding and experience with environmental policy
  - are comfortable with handling large data sets, making decisions, and thinking creatively
  - collaborate well in a multidisciplinary team, remotely and in person
  - can work with the software program R and user-created packages (at least one person)
  - can work with ArcGIS or other spatial analysis software (at least one person)
  - are fluent in English (at least one person)
- 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 (optional)
  - engage policy makers early: informing government policies to improve ocean health is most effective if there is early interest and engagement from government agencies
  - requires ongoing communication during Index development to best inform management actions that could have measurable impacts.
  - repeated assessments as new data become available enable tracking ocean health through time and evaluating management priorities

5 Conducting a Regional Assessment

5.1 What to expect when conducting a regional assessment

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

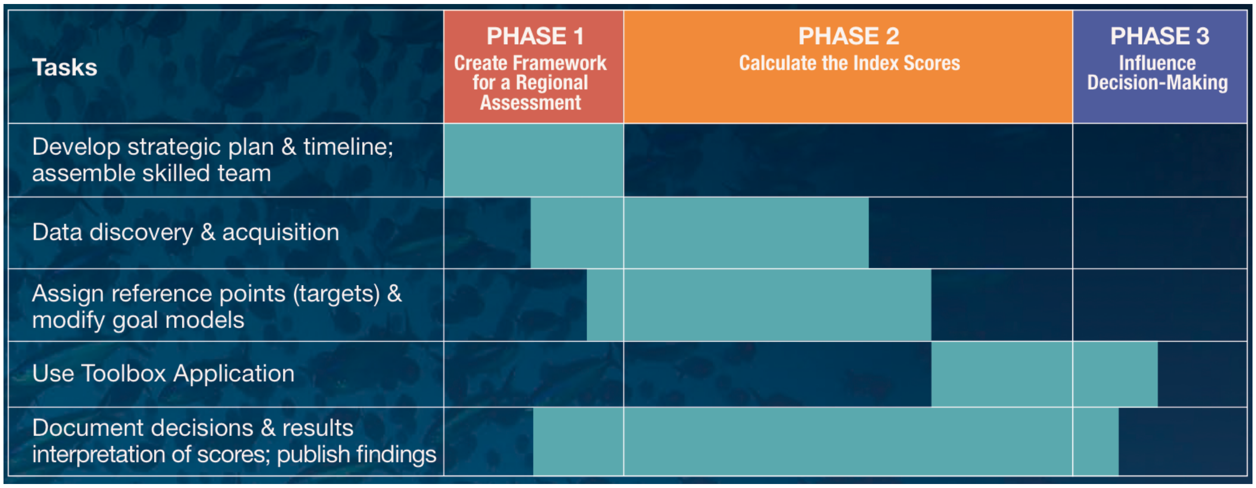
5.1.1 Timeline

The time required to complete a regional 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 for strategic planning, discovering and gathering data, and developing reference points and models, to comprise > 80% of the time allotted for the regional assessment.

5.2 What is provided

The Ocean Health Index Toolbox can be used to calculate scores for regional assessments. When you begin a regional assessment, you will be provided with a **repository**: a set of Toolbox files and software scripts specific to your study area. The data in the files provided serve as a template: they are the data used in the global assessments, extracted for your study area. These data files will need to be updated with locally



available data and indicators so as to give a more fine-scale assessment of ocean health in your study area. However, if better data are not available, it is possible to use the files provided.

Our team of scientists and managers is prepared to provide guidance for regional assessments, from initial meetings to discussions about model development to disseminating results.

5.3 Points to remember

We recommend to remember the following as you develop your approach:

- People are part of ocean health
  - economic and social data are included, and certain terrestrial data near the coast
- Document all decisions made
  - document data sources, urls, date of access, reference points set, why models were modified the way they were (and not other potential ways)...
  - important for transparency, describing methods and explaining results in reports and publications, and for reproducibility (for any future comparable assessments in your study area)
- Goal models should be modified to capture local characteristics and priorities of the region
  - how goal models are developed depends on what is important locally and what data/indicators are available.
- Assessments can use a mixture of regional-, country- and global-scale data
- Scores are calculated by region
  - comparing scores between subcountry regions is a main reason of conducting a regional assessment
  - regional scores are combined by weighted average to calculate scores for the study area
  - goal models are the same across all regions; data are specific to the region. For example, the carbon storage goal model is calculated in the same way for each region, but which habitats are present in each region, and the area and condition of those habitats 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 the point in time. For example if fisheries data are available from 1980-2011 and tourism from 2008-2012; these can be used together to calculate Index scores, which will be the representation of current ocean health

5.4 Checklist: To Do Before Using the Toolbox

Most of the time spent while conducting a regional assessment occurs before using the Toolbox, although being familiar with the Toolbox's composition and structure can help guide you. The following will not be checked-off in sequence: there is a lot of back and forth as you discover data, develop reference points and models, revisit other data possibilities.

Here is a checklist of decisions and steps that must be done before the Toolbox can calculate regional goal scores:

- Understand the philosophy of the Ocean Health Index
  - understand what goals represent and how they are modeled
  - understand what pressures and resilience are included
  - understand how reference points are set
- Identify local characteristics and priorities
  - should any goals be removed?
  - should any goals be redefined?
  - should other goals be added?
  - should goals be weighted unequally?
  - what are pressures to the local system?
  - what resilience measures (laws, regulations) are in place locally?
  - what local cultural preferences or priorities should be captured in the assessment?
- Decide the spatial scale for regions within the study area
  - we recommend multiple regions
  - regions within the study area should be at the smallest scale the data allow
  - in what spatial scale are data most frequently reported?
  - in what spatial scale are policy decisions made (optional)?
- Be familiar with the global inputs to your Toolbox repository
  - understand the data and models used in global assessments
  - prioritize which data and models should be updated
  - become familiar with the Toolbox framework for your study region: **ohi-science.shinyapps.io/[study_area]**
  - example: ohi-science.shinyapps.io/colombia
- Discover and gather appropriate data and indicators
  - what local data and indicators are available for goal models?
  - what local data and indicators are available pressures and resilience?
  - how would reference points be set for local data?
  - do local data and indicators capture the philosophy of the Ocean Health Index?
  - are local data and indicators at the appropriate spatial and temporal scales?
  - process and format data and indicators to create data layers* for the Toolbox
  - use the Toolbox repository as a registry to organize data layers
- Modify goal models and set reference points:
  - can goal goal models be refined using locally available data and indicators?
  - can reference points be refined using locally available data and indicators?

* Each data component that is included in the OHI is called a **data layer** because it will be combined with others to create the most complete picture of ocean health. Many data layers are rescaled from 0-1 to be combined with others on the same unitless scale.

5.5 Discovering and Gathering Appropriate Data and Indicators

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

Index scores are a reflection of data quality, and thus accessing the best data and indicators available is of highest importance.

5.5.1 Data sources

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

- government reports
- government websites
- academic literature
- masters and PhD theses
- university websites
- non-profit organizations

All data will be rescaled to specific reference points (targets) before being combined; therefore setting these reference points at the appropriate scale is a fundamental component of any OHI assessment. This requires the regional assessment team to interpret the philosophy of each Index goal and sub-goal using the best available data and indicators.

5.5.2 Data gathering responsibilities

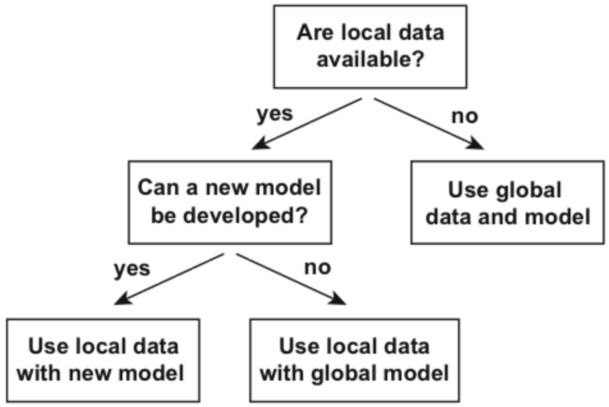
Gathering appropriate data requires searching for and accessing freely-available data. It is important that team members responsible for data discovery make thoughtful decisions about whether data are appropriate for the regional assessment, and that they also get feedback from the full team to discuss the merits of different data sources. Data discovery and acquisition can be quite an iterative process, as there are both practical and philosophical reasons for including or excluding data, in addition to requiring access to the data.

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 so that you will be able to find it again in the future.

5.5.3 The process of data discovery

In terms of philosophical considerations, the most important thing to remember when gathering data is that the data must contribute to measuring ocean health. Many data sources that enhance our knowledge of marine processes may not 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 would 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, and the US West Coast. If finer-resolution local data were available in the study area, they could be used either in a newly developed regional goal model using locally appropriate and informed approaches, or in the existing global goal model. When local data were not available, the same global-scale data were used with the original global goal model, 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:



Searching for data requires exploring data sources beyond any single discipline, and a good place to start is with an internet search. Internet searches can lead to published data in government and non-governmental organization reports, peer-reviewed articles, and masters and doctoral dissertations. Not everything will be freely available online but it is sometimes possible to request access.

It is good practice to keep detailed notes of attributes of each potential data layer, since there may be different options to work with. Searching for data by goal is a good approach, although some data layers will be used for multiple goals.

5.5.4 Requirements for data layers

Four requirements to remember when investigating (or 'scoping') potential data layers are:

1. relevance to ocean health
2. how to the reference point
3. spatial scale
4. temporal scale.

5.5.4.1 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.

5.5.4.2 Reference point As each data layer must 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:

- Is there a known relationship associated with these data?
- Have policy targets been set regarding these data?
- Would a historic target be appropriate?
- Could a region within the study area be set as a spatial target?

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

5.5.4.4 Appropriate temporal scale Data must be available for at least five years to calculate the trend. Longer time series are preferable because this can be used to set temporal reference points.*

* It is not always possible to meet the spatial and temporal requirements with each data layer. In these cases it can still be possible to use these data if appropriate gap-filling techniques are used. It is important that data satisfy as many of these requirements as possible, and in cases where creative ways of working with such data are not possible, it might be better to exclude these data from the analyses and try a different approach.

5.5.5 Notes about data and regions

Final calculated scores by region will be represented on a map in addition to the flower plot. The map displays scores in the exclusive economic zone (EEZ) of the region. This is a visualization that exactly maps the availble information of some data layers, but not all. Therefore, available data do not need to have been collected for all of the region's EEZ, but they need to be available for the region itself.

Figure 1: Scores will be presented in the EEZ of each region, even if individual data layers do not all extend to the EEZ

5.5.6 Example: US West Coast data discovery

Below are examples of some decisions made when exploring available data for the US West Coast regional assessment. Determining whether certain data could be included started with a good understanding of the data layers and models included in the global assessment, and because 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.

5.5.6.1 Reasons data were excluded There are a lot of existing data that contribute to our scientific understanding of ocean processes and interactions but that are not ideal for the OHI. Reasons to exclude data occur both on a practical level (do data adhere to the requirements above?) and on a philosophical level, which requires reflecting on the relationship with ocean health. Some common reasons for excluding data are listed below:

- **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, Oregon and Washington did not have these same data so they were not used.
- **There is not a clear and scientifically proven connection between the metric described by 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 is quite variable and is driven primarily by abiotic natural forcing (wave/storm disturbance and temperature) and thus kelp coverage is not a good metric of ecosystem health. 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 the ocean**. 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 ocean itself, so only biogenic habitats were included in the calculation of this goal. These data can be included as a pressure due to habitat loss.
- **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 ocaean health since they assess only 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.

5.5.6.2 Creative approaches to using data

- **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, available data measure the current extent of seagrass habitats, however, these only exist for one time point in most areas so could not be used to calculate the trend or set a historical reference point. As these were the best data available for habitat coverage, we built a model to calculate the status and trend of seagrass habitats using other data that were available over time. A reasonable approach was to model the pressures exerted on seagrasses over time as a proxy for seagrass health.

5.6 Formatting Data for the Toolbox

5.6.1 Introduction

The Ocean Health Index Toolbox App 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). Data layers (data input) each have their own .csv file that are combined within the Toolbox in model calculations. These data layers are used for calculating goal scores, meaning that they are inputs for status, trend, pressures, and resilience. In the global analysis, there were over 100 data layer files included, and there will be as many in regional applications, no matter what the spatial scale. This document describes and provides examples of how to format data for the Toolbox App.

Ocean Health Index goal scores are calculated at the scale of the reporting unit, which is called a '**region**' and then combined using a weighted average to produce the score for the overall area assessed, called a '**study area**'. The OHI Toolbox App expects each data file 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*. 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).

In the example below, there are two data layers files (tr_jobs_total.csv and np_harvest_tonnes.csv) that have data for four and two regions respectively (1-4, and 5-6). 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).

Example of data in the appropriate format:

It is important that data prepared for the Toolbox App 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 a thoughtful decision to most reasonably fill the gap. 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.

Note that the DataLayer column has been included for clarity in the examples below, but should be ommitted in the final .csv file.

5.6.2 Temporal gapfilling

Temporal gaps are when some data are available for a region, but there are missing years. The Toolbox requires data for each year for every region.

Many times, creating a linear model is the best way to estimate data and fill temporal gaps. 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 A.

Steps to temporally gapfill data (assumes linearity):

tr_jobs_total.csv		
rgn_id	year	count
1	2005	403.839252402164
1	2006	413.460515936812
1	2007	423.968955354259
1	2008	434.160401973605
1	2009	442.114014419865
1	2010	448.332865261536
2	2005	1,403.95122647195
2	2006	1,437.39964600851
2	2007	1,473.93234143293
2	2008	1,509.36300820354
2	2009	1,537.01382194288
2	2010	1,558.63371949984
3	2005	1,559.79523327144
3	2006	1,596.95655652104
3	2007	1,637.54452219044
3	2008	1,676.90812977053
3	2009	1,707.62829059485
3	2010	1,731.64808025513
4	2005	0
4	2006	0
4	2007	0
4	2008	0

np_harvest_tonnes.csv			
rgn_id	product	year	tonnes
5	ornamentals	2005	4
5	ornamentals	2006	3.75
5	ornamentals	2007	3.5
5	ornamentals	2008	4.25
5	ornamentals	2009	3333333
5	ornamentals	2010	4.5
5	shells	2005	164.5
5	shells	2006	184.25
5	shells	2007	215.25
5	shells	2008	225.5
5	shells	2009	6666667
5	shells	2010	252.5
6	corals	2005	17
6	corals	2006	8
6	corals	2007	0
6	corals	2008	0
6	corals	2009	0
6	corals	2010	0
6	shells	2005	6.25
6	shells	2006	8.75
6	shells	2007	12.25
6	shells	2008	13.75

Region	Year	DataLayer	Value
A	2005	tourists_count	177.14
A	2006	tourists_count	
A	2007	tourists_count	
A	2008	tourists_count	212.99
A	2009	tourists_count	228.81
B	2005	tourists_count	580.98
B	2006	tourists_count	730.18
B	2007	tourists_count	717.00
B	2008	tourists_count	851.44
B	2009	tourists_count	836.68
C	2005	tourists_count	129.69
C	2006	tourists_count	173.45
C	2007	tourists_count	229.86
C	2008	tourists_count	231.44
C	2009	tourists_count	
D	2005	tourists_count	397.00
D	2006	tourists_count	566.00
D	2007	tourists_count	
D	2008	tourists_count	1154.00
D	2009	tourists_count	1570.00

In this data layer, there are three regions that have missing values for one or more years and will require temporal gapfilling: Regions A, C, D.

No regions in this example require spatial gapfilling.

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 in years (2005, 2006, etc...), the y-axis is in 'tourist_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).

	B	C	D	E	F	G	H	I	J
39						Steps to temporally gapfill data:			
40						1	2	3	4
41	Region	Year	DataLayer	Value		Slope	Intercept	y = mx + b	Value (final)
42	A	2005	tourists_count	177.14				176.70	177.14
43	A	2006	tourists_count					189.39	189.39
44	A	2007	tourists_count					202.08	202.08
45	A	2008	tourists_count	212.99				214.78	212.99
46	A	2009	tourists_count	228.81		12.69	-25273.89	227.47	228.81

Formula SLOPE($E$42:$E$46, $C$42:$C$46)

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 as highlighted in the figure below.

	B	C	D	E	F	G	H	I	J
39						Steps to temporally gapfill data:			
40						1	2	3	4
41	Region	Year	DataLayer	Value		Slope	Intercept	y = mx + b	Value (final)
42	A	2005	tourists_count	177.14				176.70	177.14
43	A	2006	tourists_count					189.39	189.39
44	A	2007	tourists_count					202.08	202.08
45	A	2008	tourists_count	212.99				214.78	212.99
46	A	2009	tourists_count	228.81		12.69	-25273.89	227.47	228.81

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

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 into the y = mx + b equation, as illustrated in the figure below, to calculate the unknown 'tourist_count' for a given year (189.39 in 2006, and 202.08 in 2007).

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

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

5.6.3 Spatial gapfilling

Spatial gaps are when no data are available for a particular region.

	B	C	D	E	F	G	H	I	J
39						Steps to temporally gapfill data:			
40						1	2	3	4
41	**Region**	**Year**	**DataLayer**	**Value**		**Slope**	**Intercept**	**y = mx + b**	**Value (final)**
42	A	2005	tourists_count	177.14				176.70	177.14
43	A	2006	tourists_count					189.39	**189.39**
44	A	2007	tourists_count					202.08	**202.08**
45	A	2008	tourists_count	212.99				214.78	212.99
46	A	2009	tourists_count	228.81		12.69	-25273.89	227.47	228.81

Formula ($G$46 × C43)+ $H$46

Region	**Year**	**DataLayer**	**Value**
A	2005	tourists_count	177.14
A	2006	tourists_count	201.39
A	2007	tourists_count	199.81
A	2008	tourists_count	212.99
A	2009	tourists_count	228.81
B	2005	tourists_count	
B	2006	tourists_count	
B	2007	tourists_count	
B	2008	tourists_count	
B	2009	tourists_count	
C	2005	tourists_count	129.69
C	2006	tourists_count	173.45
C	2007	tourists_count	229.86
C	2008	tourists_count	231.44
C	2009	tourists_count	221.95
D	2005	tourists_count	397.00
D	2006	tourists_count	566.00
D	2007	tourists_count	591.00
D	2008	tourists_count	1154.00
D	2009	tourists_count	1570.00

In this data layer, Region B is missing from this dataset and requires spatial gapfilling.

No temporal gapfilling is required in this example.

To fill gaps spatially, assumptions must be made that one region is like another, and data from another region will be substituted in place of the missing data.

Depending on the data, this can be done simply by assuming that two regions are similar enough that their data could be exactly copied, or a proportion of those values could also be applied. This will depend on the type of data, and the properties of the region. Each data layer can be gapfilled using a different approach when necessary.

Characteristics of a region that can influence spatial gapfilling:

1. proximity: can it be assumed that nearby regions have similar properties?
2. larger regions: Are data reported in larger regions and can those data be used for subregions?
3. demographic information: can it be assumed a region with a similar population size has similar data?

Spatial gapfilling example:

To spatially gapfill Region B requires thinking about the properties and characteristics of the region and the data, tourists_count.

Here are properties that can be important for decision making:

Region B: - is located between Region A and C - is larger than Region A - has similar population size/demographics to Region C - has not been growing as quickly as Region D

There is no absolute answer of how to best gapfill Region B. Here are a few reasonable possibilities:

Assign Region B values from: - Region A - Region C - Region A and C averaged

In the example below, the decision was made to gapfill Region B using the mean of Regions A and C 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.

Region	Year	DataLayer	Value
A	2005	tourists_count	177.14
A	2006	tourists_count	201.39
A	2007	tourists_count	199.81
A	2008	tourists_count	212.99
A	2009	tourists_count	228.81
B	2005	tourists_count	
B	2006	tourists_count	
B	2007	tourists_count	
B	2008	tourists_count	
B	2009	tourists_count	
C	2005	tourists_count	129.69
C	2006	tourists_count	173.45
C	2007	tourists_count	229.86
C	2008	tourists_count	231.44
C	2009	tourists_count	221.95

Region	Year	DataLayer	Value
A	2005	tourists_count	177.14
A	2006	tourists_count	201.39
A	2007	tourists_count	199.81
A	2008	tourists_count	212.99
A	2009	tourists_count	228.81
B	2005	tourists_count	153.42
B	2006	tourists_count	187.42
B	2007	tourists_count	214.84
B	2008	tourists_count	222.22
B	2009	tourists_count	225.38
C	2005	tourists_count	129.69
C	2006	tourists_count	173.45
C	2007	tourists_count	229.86
C	2008	tourists_count	231.44
C	2009	tourists_count	221.95

Formula AVERAGE(J43, J53)

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

5.6.4 Long formatting

The Toolbox expects data to be in 'long' or 'narrow' formatting. 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:

		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

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: - 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),]
```

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 more easy to read for humans (R and the Toolbox can read these data without this final step):

Example of data in the appropriate format:

With 'narrow' format, each row of data provides complete and unique information, and does so with as few columns as possible.

Data layers in this format can be easily combined with other data layers: the range of years available can be different for each data layer, and there are minimal column names.

5.6.5 Gapfilling examples from 2013 Global Assessment

Data gap filling procedures:

GDP_USDx1000		
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

governance_indicator		
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

[excerpted from 2013 Global Supplementary Methods, www.oceanhealthindex.org/About/Methods/]

Many data layers had sufficient global coverage to merit inclusion in the calculation of the Index, yet still had gaps (i.e., regions not represented) that needed to be filled to calculate scores for all Index regions. In this current 2013 assessment, unrepresented regions often included many of the new (small) reporting regions (Table S1). Data used for calculation of goal trends also required temporal replication over the previous five years (minimum), and this was not always available. In both cases (data with spatial and temporal gaps) we attempted to fill gaps in a manner as simple and transparent as possible.

In regions where data were missing, or the data were considered too outdated to be informative, we adopted gap-filling procedures based on a hierarchical decision tree. These rules were only applied to data that were missing but known to exist in relevant Index regions: no gap-filling was done for regions where the data layer or goal were deemed not applicable. Cases where gap-filling was not appropriate occurred: a) for goals that entail local human activities (i.e. artisanal opportunities, natural products, tourism & recreation, and coastal livelihoods & economies), no gap-filling was applied in uninhabited regions (as opposed to goals such as biodiversity and sense of place that matter even in uninhabited locations, where gap-filling was applied in uninhabited regions) b) for goals capturing extractive uses (i.e. food provision, natural products), no gap-filling was applied in regions that did not report them, under the assumption that such activities occur only where reported, and c) for goals based on the presence of certain habitats (i.e., carbon storage, coastal protection, and biodiversity), no gap-filling was applied in regions where the relevant habitats were not present in the global maps of habitat cover available. A particular case of gap-filling decisions for habitat data is for the "exposure" component of the natural products goal. There were regions that reported the harvest of a product, but, according to the habitat maps, the habitat(s) where such a product would be harvested were missing in that region. In these cases of mismatches, the habitat map was assumed to have gaps (i.e., the harvest data in that region was assumed to be "real"), and to gap-fill the habitat data, a georegional average (see below) of exposure values was used. If, however, a product was reported for a region that includes some offshore territories that in 2013 are reported as separate regions, it was assumed the product is harvested only in the regions with documented extent of the relevant habitats (see section below on "special gap-filling rules" for new reporting regions).

We used three different methods to gap-fill missing data within reporting regions: temporal, by using data from previous years; spatial, by using averages from nearby regions, and for a few exceptional cases, fixed scores or alternate datasets used as proxies. If a region was present in time-series data with years of data missing, temporal gap-filling was always attempted first, with spatial gap-filling used only when data were too outdated or for regions that were completely absent. To decide if a region's values were outdated, we established a year prior to which the data could not be used. This “threshold year” was in most cases set to be 10 years prior to the most recent sampled year in the dataset. A few exceptions were made in the case of fertilizer trends, pesticide trends, natural products monetary value, livelihoods and economies (see data-layer sections for more details).

Temporal gap filling:

Gaps in time-series data for each reporting region were filled using one of the following three approaches, each applied when appropriate rather than hierarchically:

1. Previous year: the value from the previous year is used to replace the current year's value. This approach assumes no change in the past 2 years and was implemented in cases where the current year could have been missing due to a delay in reporting at the time the Index was calculated. This approach was only implemented for the natural products goal (i.e. for harvested tonnage of each product), and for the mariculture subgoal (i.e. for harvested tonnage of each species).

2. Fitted values: the available data were used to fit a linear model to the time series and predict missing values. Data within a 10-year window centered on the gap year (i.e. ± 5 years) were used as input in the fitted model. When the missing year was less than 5 years from the most recent year in the data set, the window was shifted to still include 10 years of data even though it was no longer centered upon the missing year. Temporal gap-filling of this kind was done when at least two years of data were available.

3. Fitted values for data older than 10 years: in the cases of livelihoods & economies, the goals based on habitats, i.e. coastal protection, carbon storage and biodiversity, and the monetary value data for natural products, due to the scarcity of data available, the 10 year rule was relaxed so as to include older data. For more details see Halpern et al. (2012), and see the sections 4.3 and 5.53 on natural products value data.

Spatial gap filling:

For some reporting regions (e.g., small regions that are remote territorial holdings of countries) and/or certain data layers, no data exist, or they have no data after 2002, and thus temporal gap-filling is not an option. Thus, we used data to gap-fill spatially with the exception of livelihoods & economies, and the goals based on habitats, i.e. coastal protection, carbon storage and biodiversity, where older data were used to gap-fill temporally, following the same rules as in Halpern et al. (2012). For spatial gap-filling, we used one of the following three methods, each applied when appropriate rather than hierarchically:

1. Georegional: in general, we assumed nearby regions (with data) could serve as reasonable proxies for a region missing data, and so we averaged values from geographically nearby regions to fill the gap. We used two levels of spatial aggregation to determine which regions defined ‘nearby’, derived from United Nations definitions of geopolitical regions (Table S7). The first level aggregates geographically closer regions (preferred), while the second defines much larger regions, in some cases coinciding with entire continents (used only when no countries within the ‘first level’ aggregation had data).

2. Sovereign country + georegional: often data were missing for small remote islands. Several of these are under the governance of distant countries that would not fall within the same georegion. For institutional and socioeconomic data, we assumed that offshore domains would have more in common with their administrative country than with geographically closer regions. In these cases, the values from the administrative country were used to gap-fill when present, otherwise the georegional averages were used as described above.

3. Habitat regions: for goals using habitat data (i.e., natural products, carbon storage, coastal prediction, and biodiversity), when the habitat extent data indicated that a given habitat was present, but data on its condition was missing, geo-ecological regional averages were used specific to each habitat type (see Halpern et al. 2012, Selig et al. 2013 for descriptions of these regions). Because no habitat data could be updated for this current assessment, we did not need to repeat this method, but its implications for results remain.

Special gap-filling rules:

In a few cases, we adopted a method unique and appropriate to the specific situation.

1. Southern Islands: For a group of small, remote islands found in the Southern oceans (see Table S6), data are often missing. Due to their remote location, a spatial gap-filling approach would result in values from very distant regions, that may have no similarities with these islands, being used to gap-fill, thus leading to biased scores. For the tourism & recreation and coastal livelihoods & economies goals, we assume that these scarcely inhabited areas do not develop either aspect and these goals therefore drop out. For the artisanal fishing opportunities goal, on the other hand, we assigned a perfect score because we assume that there is need for it and that it is fully satisfied, since legislative or economic constraints on people's access to artisanal fishing are unlikely in these regions. Note that this only applies to the southern islands that are inhabited (Table S6); uninhabited Southern Islands get no score as do all other uninhabited regions.
2. Using other data layers as a proxy: for the evaluation of trends in pesticides, fertilizers and trash pollution, it was assumed that the relative rate of change would mimic that of population. Hence, this was used when data to calculate these trends were missing. On the other hand, the fertilizer and pesticide consumption used as input values to calculate pressures were gap-filled by using a linear relationship between these two layers.
3. New reporting regions: Some gap-filling was necessary even when the data sources used were identical to those in the 2012 calculation (i.e., no updated data were available), due to the presence of new, better resolved, reporting regions added for this 2013 calculation (see section 3). Most of the new reporting regions were offshore territorial holdings that in 2012 had been aggregated with their administrative country. For spatially explicit data sources this was not an issue, as we simply re-calculated the values using the new regional delimitations (i.e., all calculations based on habitat coverage, including the soft bottom layer, the exposure layers for the natural products status, the relative weights assigned to the pressure and resilience matrices pertinent to habitat-based goals, most of the pressure layers). However, tabular data were not always reported at the scale of the smaller reporting regions added in 2013 (e.g., trash, targeted harvest, artisanal fishing high & low bycatch, habitat destruction of subtidal hard-bottom, etc.). In these cases, values from 2012 aggregated reporting regions were disaggregated for corresponding 2013 reporting regions using one of three approaches:

- a. identical value assigned, for example with some regulatory measures used in resilience measures (the World Governance Indicators (WGI), the Convention on Biological Diversity (CBD), the Global Competitiveness Index (GCI), the Mariculture Sustainability Index (MSI), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), alien species regulations, and sector evenness); for the status and trend of habitat-based goals (habitat-specific "health" condition and its trend); for artisanal opportunities (access based on regulations reported by Mora et al. 2009); for pressures (artisanal fishing with high bycatch, and targeted harvest)
- b. weighted by the relative proportions of coastal population (namely: revenue, number of jobs, adjusted workforce size, pressure from artisanal fishing with low bycatch, and from intertidal habitat destruction)
- c. weighted by the relative proportions of corresponding EEZ area (e.g. alien species pressure).

4. Alternate data sources: for total population, data were not reported in 59 of the 2013 reporting regions. For these cases we manually searched Wikipedia for population estimates to fill in the missing values.

Gap filling calculated scores:

In two cases, gap-filling was applied to calculated values for the pertinent dimension because individually gap-filled layers would produce inaccurate results (details provided in following examples). These exceptions were:

1. the status for tourism & recreation, where relative coastal population abundance and number of employees would not be comparable if they were gap-filled using different approaches (e.g., the regional average for the population layer may not be commensurate to the tourism employment value); and

2. the calculation of sector evenness in cases where some of data for any of the sectors were gap-filled. The gap-filled values, even if they are derived from countries with much bigger or smaller populations, so that they are not commensurate in absolute terms to the gap-filled country's workforce, may be used when capturing no-net loss of jobs, as they can still provide a proxy for the rate of change in jobs, but would create potentially not comparable absolute numbers of employees per sector.

6 Installing the Toolbox for a Regional Assessment

[[develop

6.1 Getting Started

Ocean Health Index assessments have a specific organization of data files, registry files, and R scripts that work together to do calculations and present the final scores graphically. These files and scripts are packaged together in a folder called a **repository**. Each Ocean Health Index assessment has its own repository. Repositories are stored online through GitHub, which enables easy collaboration with versioning capabilities. Learn more about GitHub repositories and OHI.

It is possible to conduct a regional assessment by downloading a template repository from GitHub. We recommend having a GitHub user account and syncing with the online repository: this faciliates collaboration within your team but also allows us to provide support when you need it. However, it is possible to work independently without GitHub (after the initial download), although we cannot offer much support in this case.

Requirements: an Internet connection for the initial Toolbox App installation and continued access if syncing with GitHub (highly recommended); proficiency with data management and the coding language **R**; proficiency in spatial software such as ArcGIS (potentially, depending on the regional assessment strategy).

1. Begin a regional assessment
2. Become familiar with the Toolbox file system
3. Modify the Toolbox to calculate regional scores.

6.2 OHI and GitHub

The Ocean Health Index (OHI) Toolbox is written in R and uses GitHub, an open-source development platform, to develop and share software and data. GitHub has powerful versioning capabilities, which allows changes to be archived and tracked by each user. This is incredibly useful to not only document what work has been done, but how it differs from work done in the past, and who is responsible for the changes: it provides a record of all changes made. GitHub enables easy collaboration with others, including the OHI team.

OHI has several **repositories** (‘repos’) where data and code are stored. From the GitHub glossary:

> A repository is the most basic element of GitHub. They’re easiest to imagine as a project’s folder. A repository contains all of the project files (including documentation), and stores each file’s revision history. Repositories can have multiple collaborators and can be either public or private.

6.2.1 OHI regional assessments and GitHub

OHI-Science is the ‘owner’ of the OHI repositories stored on GitHub, and individual users contribute to these repositories when they have permission. A user works locally on their own computer, but syncs their work back to the repo on the server. Because there can be multiple users working on the same repo, there are specific steps involved, and GitHub has specific words for each of these steps, including **cloning** a repo from the server to a local repository, **committing** any changes made with a description, **pulling** any updates from the server’s repo, and finally **pushing** committed changes back to the server.

	`github.com/ohi-science/[repo]` (web)	`github.com/[user]/[repo]` (web)	`~/github/[repo]` (local)
->		-> fork	-> clone
<-	merge pull request {admin} <-	<- pull request	<- push, <-> commit

6.2.1.1 GitHub flow with *Fork & Pull Model*

where: * `[repo]` is one of OHI-Science repositories: ohicore, ohiprep, etc. * `[user]` is your GitHub username

see also: * GitHub flow in the browser

This example illustrates GitHub’s collaborative workflow with the `ohi-israel` repo owned by `OHI-Science`:

6.3 Accessing repositories with GitHub

We recommend that groups interested in conducting OHI assessments do so using GitHub, which is an online interface for version-control software called *git*. This will enable collaboration and transparency, and will provide access to the latest developments in the Toolbox software. To get started, follow the steps below. The OHI team will create a repository for your regional assessment.

It is also possible to conduct a regional assessment without GitHub. We do not recommend this because it is more difficult for you to track progress and decisions, and for us to help or advise you. However, if this is preferable, see the instructions here. We can always get your filesystem onto GitHub later.

6.3.1 Install R and RStudio

Make sure you have the most current version of R and RStudio. (Hint: type `sessionInfo()` into the R console to see which version of R you have installed, and update it if this is not the most recent version available on CRAN).

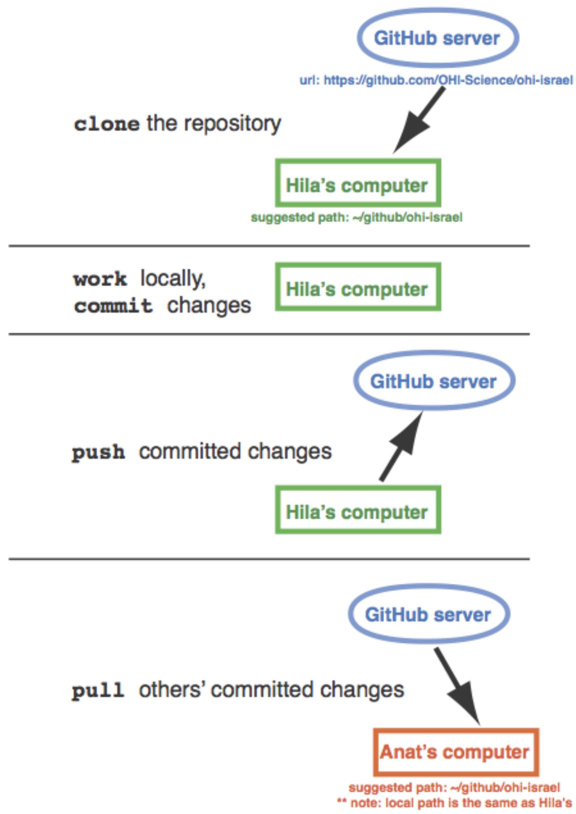


Figure 2: software required for regional assessments with version control

6.3.2 Create a GitHub account

GitHub is an online interface for *git*, and to use it you must create a GitHub account. You will use this username and password when you install *git* and access your GitHub repository (next two steps below).

6.3.3 Install *git* software

git is version-control software that you will need to install on your computer.

Download *git* and follow the install instructions. There are specific settings to select for **Windows** and **Mac**.

6.3.4 Set up your Git Identity

After downloading and installing, you will then need to set up your Git Identity, which identifies you with any changes made. You will use the command line:

- **Mac**: launch the Terminal application (Applications > Utilities > Terminal)
- **Windows**: go to command line in Windows (Start > Run > cmd)

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
```

6.3.5 Clone your ohi-[assessment] repo to your computer

The OHI team will create a repository for your assessment once you provide your GitHub username: email your username to bbest@nceas.ucsb.edu or lowndes@nceas.ucsb.edu.

The repository will be backed up and stored on github.com and you will also have a local version on your computer.

** **Important:** Please create a folder called `github` in your root directory and save the repository there. This will make collaborating possible, particularly between Macs and Windows machines. The directory for the assessment `~/github/ohi-[assessment]` will therefore be:

- on a Mac: `/Users/[User]/github/ohi-[assessment]`
- on Windows: `C:\Users\[User]\Documents\github\ohi-[assessment]`

Downloading a repository from GitHub is called **cloning** and there are multiple ways to do it. Cloning allows you to make changes on your local computer and sync them to the online repository, described elsewhere (GitHub-OHI repositories).

6.3.5.1 Cloning options

There are several options to clone the ohi-[assessment] repository to your local machine:

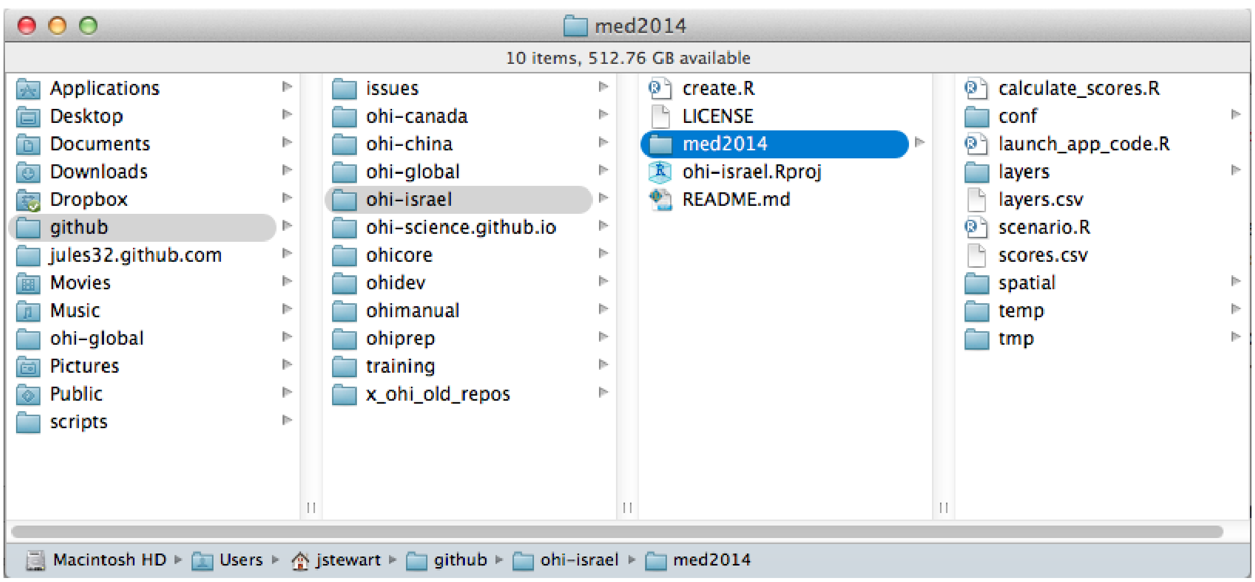
1) The GitHub App for Mac or Windows. After installing the GitHub App, log in with your username and passord. Then follow instructions for cloning (see the *Getting started guide* on a Mac and Windows)
2) The command line (Windows) or Terminal (Mac). For example, clone `ohi-israel` into the `~/github` folder:

```
cd ~/github
git clone https://github.com/OHI-Science/ohi-israel.git
cd ohi-israel
```

3) RStudio. This is best after the initial clone, since RStudio occassionally has trouble with setting the username / password.

6.3.6 Working locally

All of the files available from the online server repository `https://github.com/OHI-Science/ohi-[assessment]` are now cloned on your local computer, in the location you specified. We recommend cloning the repository to this file path: `~/github/ohi-[assessment]`.



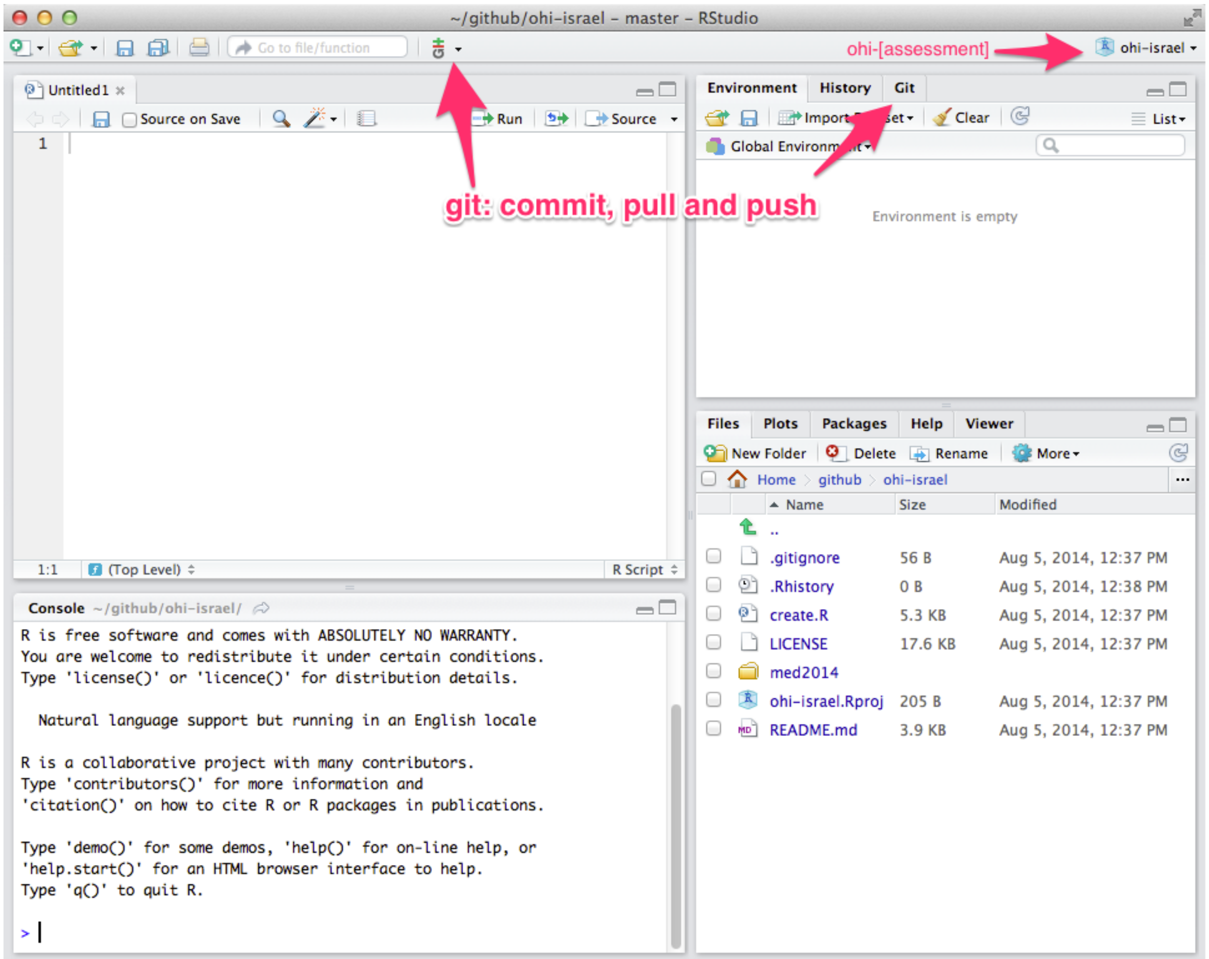
You will work on your computer to change the files in `~/github/ohi-[assessment]` to reflect the desired modifications your team has identified for your regional assessment. All changes within this folder will be tracked by GitHub when you commit and sync these changes, *even if you make these changes outside of R or RStudio*. This means that you can delete or paste files in the Mac Finder or Windows Explorer, edit `layers.csv` and `goals.csv` in Excel or a text editor, and modify `functions.r` in RStudio, and commit all these changes to GitHub to track the changes you make.

6.3.7 Committing and pushing changes locally

Committing and pushing changes can be done using RStudio or the Github App.

6.3.8 Using RStudio to commit and push changes to GitHub ohi-[assessment] repository

Launch your `ohi-[assessment]` project in RStudio by double-clicking the `ohi-[assessment].Rproj` file. From RStudio, Commit locally, associating a message with each set of changes.



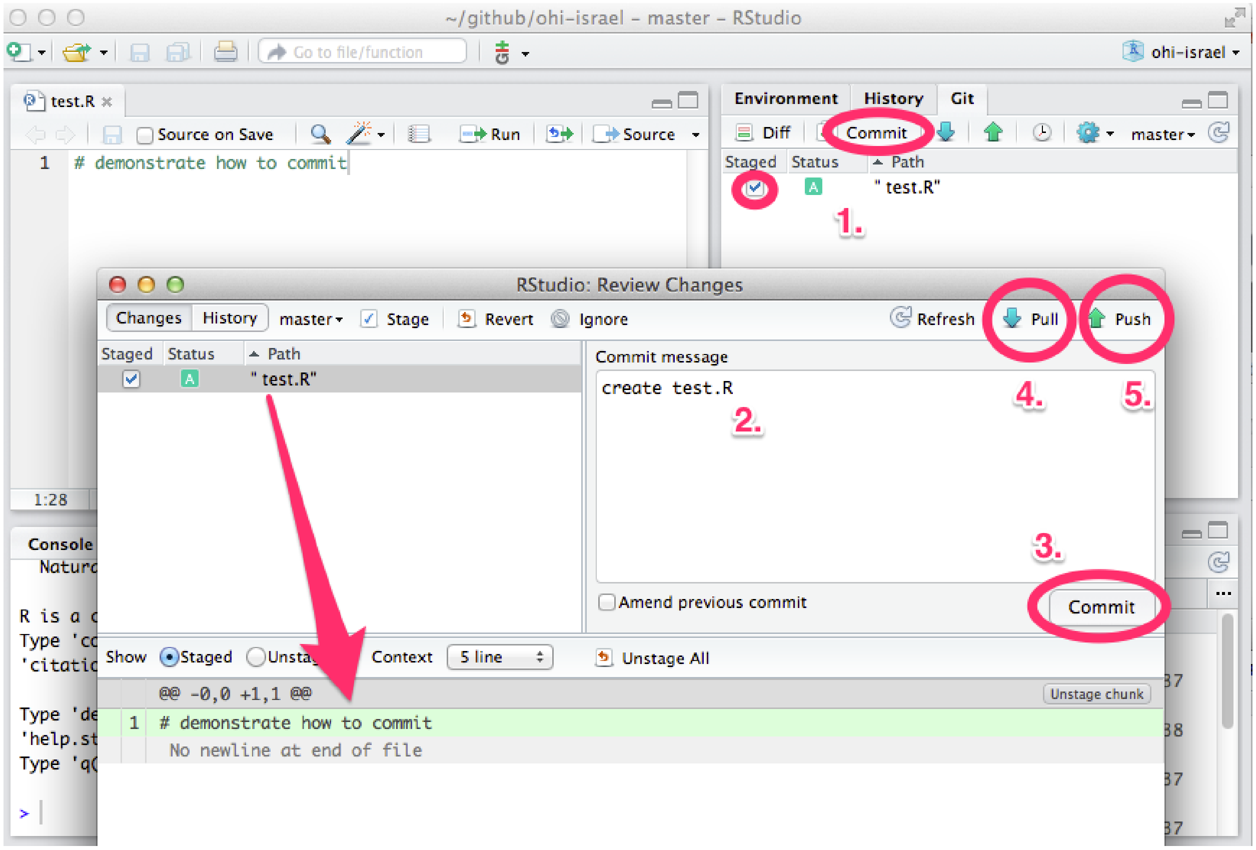
When you modify or add a file, the file will appear in the 'Git' window. In the example below, the file `test.R` was created.

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 repo. This is important to ensure there are no conflicts with updating the online repo.

5. Push your committed changes to the online server at `github.com/OHI-Science/ohi-[assessment]`. Your changes are now visable online.



6.3.9 Using Github App to push commits to GitHub ohi-[assessment] repository

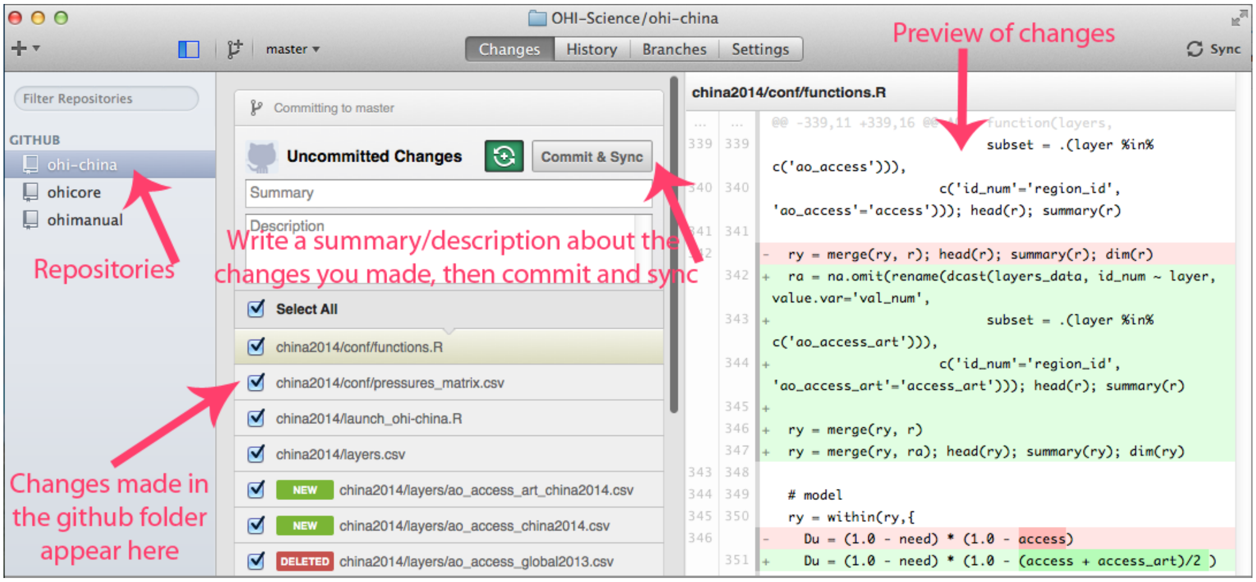
The Github App can also be used to commit and sync any changes made locally in the github folder. To do so, write a summary and description in the respective message bars in the Github App window, then click on commit and sync.

6.3.10 Keeping syncronized

Always pull before pushing commits. This is the best way to avoid merging errors due to other users in your group modifying files.

6.3.10.1 More Information

- presentation: Reproducible science with the Ocean Health Index
- wiki: Using GitHub



6.4 Accessing repositories without GitHub

6.4.1 OHI regional assessments without GitHub

It is possible to conduct a regional assessment without having a GitHub account. You can do a one-time download from the GitHub repository and then work locally on your computer without syncing to the GitHub server. We do not recommend this because it is more difficult for you to track progress and decisions, and for us to help or advise you. We recommend accessing a repository with GitHub but provide instructions here of how to access a repository without Github. We can always get your filesystem onto GitHub later.

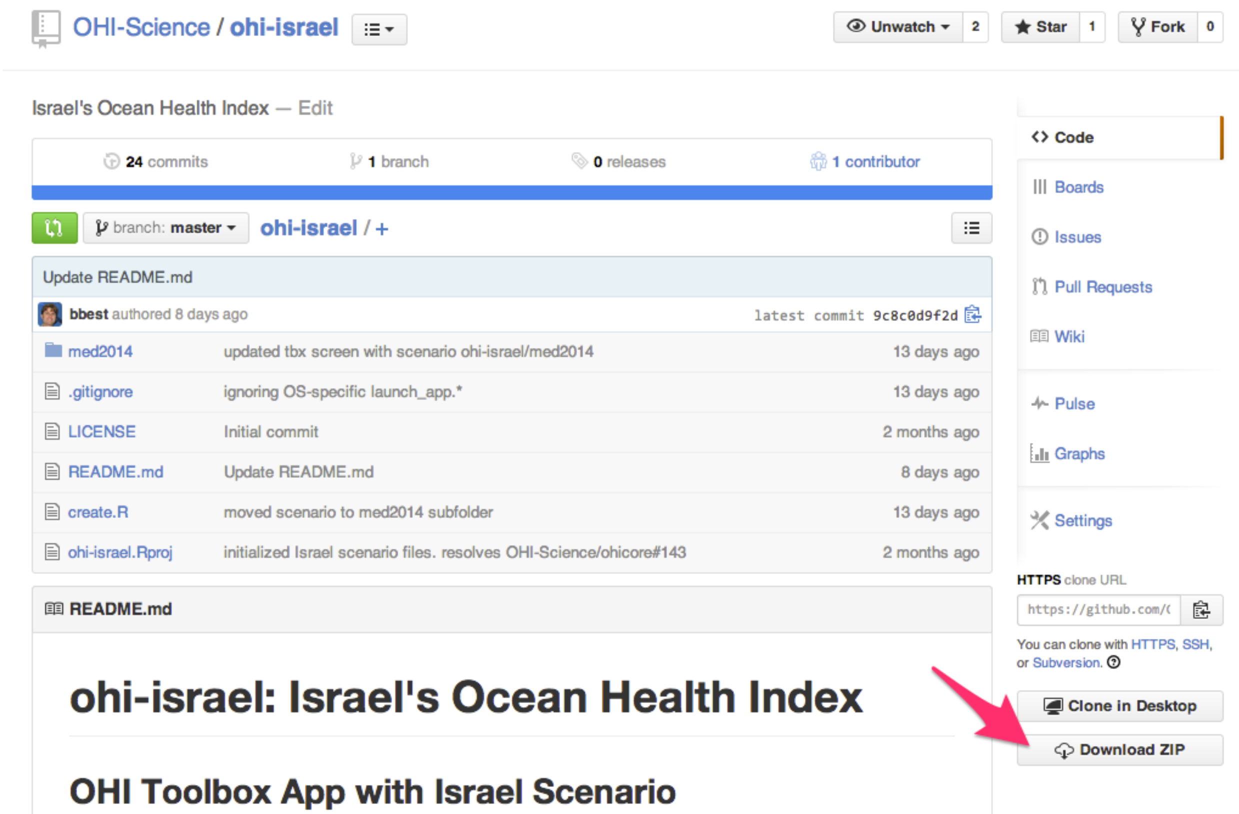
6.4.2 Install the latest version of R

Download **R** and install this 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 websited. Compare what is available from their wesite 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. RStudio also has great compatibility with GitHub so you can collaborate with your team directly from your R code. RStudio does not get updated as often as R does, but it is good to check for updates regularly.

6.4.3 Download the repo to your computer

Contact the OHI team (bbest@nceas.ucsb.edu or lowndes@nceas.ucsb.edu) to create a repository for your group. The repository will be stored on github.com and called `OHI-Science/ohi-[assessment]`: for example, `github.com/OHI-Science/ohi-israel`. When your repository has been created, enter the url in to an internet browser (for example, `github.com/OHI-Science/ohi-israel`). Click `Download ZIP`.



6.4.4 Working locally

Unzip the downloaded folder `ohi-[assessment]-master` and save the folder on your computer. We recommend creating a folder called `github` in your root directory and saving your repository to this file path: `~/github/ohi-[assessment]`. This will make collaborating much simpler since everyone will work with the same file path.

You will work on your computer to change the files in `~/github/ohi-[assessment]` to reflect the desired modifications your team has identified for your regional assessment.

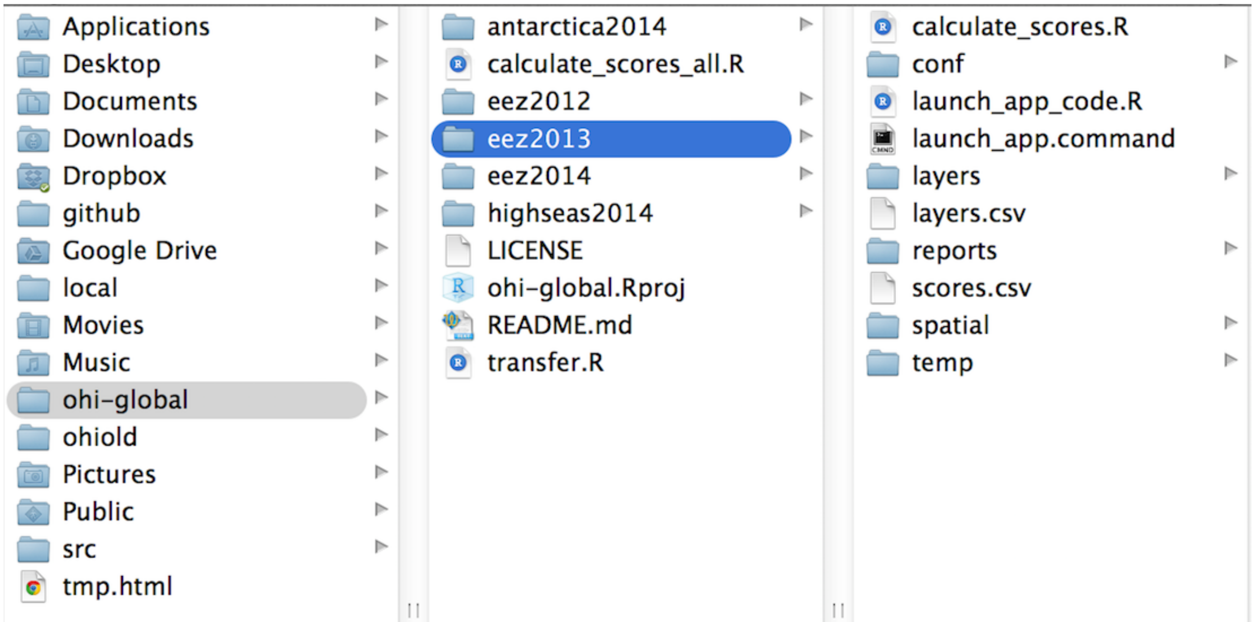
6.5 OHI Toolbox File System

This section describes the files within the ohi-[assessment] folder that you have accessed by either cloning through GitHub and RStudio or downloading to your computer from GitHub.

6.5.1 Assessments and scenarios

Within the **ohi-**[**assessment**] folder is the **scenario** folder. The scenario folder contains all the data, functions and other files required to calculate the Ocean Health Index. To calculate the Index for a different region or with new data or models, you will modify the files within this folder (default data is from the global assessment).

In this example, **ohi-global** is the assessment folder and **eez2013** is the scenario.



6.5.2 *layers.csv*

`layers.csv` is the registry that manages all data to be used in the Toolbox.

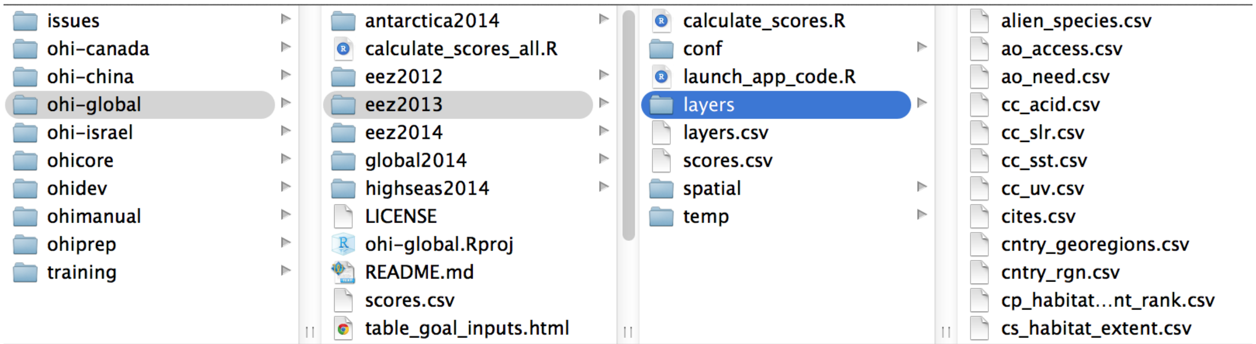
	A	B	C	D	E	F	G
1	targets	layer	name	description	fld_value	units	filename
2	AO	ao_access	Fisheries manage	The opportunity fc	value	value	ao_access.csv
3	AO	ao_need	Purchasing powe	The per capita pu	value	value	ao_need.csv
4	CW	cw_coastalpopn_tren	Coastal human p	Coastal populatio	trend	trend score	cw_coastalpopn_tr
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

Each row of information represents a specific data layer that has been prepared and formatted properly for the Toolbox. The first columns contain information inputted by the user; other columns are generated later by the Toolbox App as it confirms data formatting and content. The first columns have the following information:

- **targets** indicates how the data layer related goals or dimensions. 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** 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 Toolbox App 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 Toolbox App 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 Toolbox App under the drop-down menu when the variable type is 'input layer'.
- **fld_value** indicates the units along with the units column.
- **units** some clarification about the 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 'layers'.

6.5.3 *layers* folder

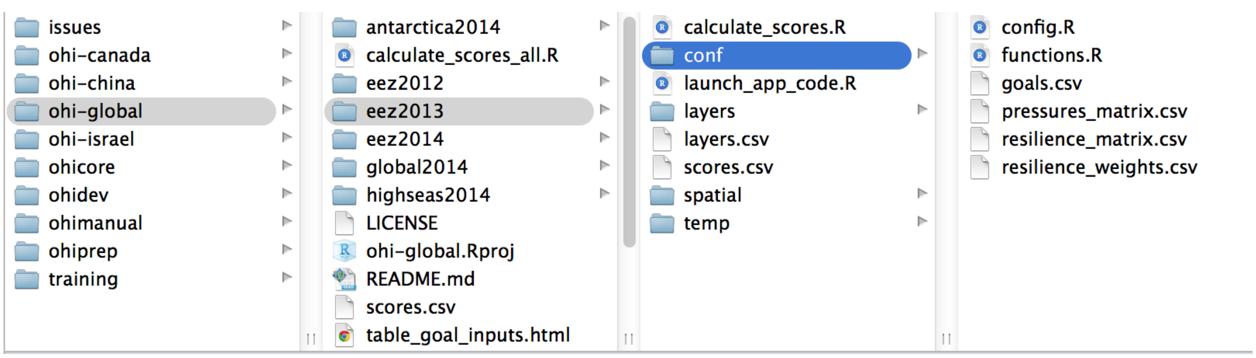
The `layers` folder contains every data layer as an individual *.csv* file. The names of the *.csv* files within the layers folder correspond to those listed in the *filename* column of the `layers.csv` file described above. All *.csv* files can be read with text editors or with Microsoft Excel or similar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



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. Open a `layers/*.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. Please see the section on *Formatting Data for the Toolbox* for further details and instructions.

6.5.4 *conf* folder

The `conf` folder includes 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.R*, *resilience_matrix.csv*, and *resilience_weights.csv*).



6.5.4.1 *config.r*

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

6.5.4.2 *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`.

6.5.4.3 *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 Toolbox App. `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).

6.5.4.4 ***pressures_matrix.csv***

`pressures_matrix.csv` describes the layers ('layers' column in layers.csv) needed to calculate pressure categories. The matrix has weights assigned that were determined by Halpern *et al.* 2012 (*Nature*) based on scientific literature and expert opinion.

6.5.4.5 ***resilience_matrix.csv***

`resilience_matrix.csv` describes the layers ('layers' column in layers.csv) needed to calculate resilience categories.

6.5.4.6 ***resilience_weights.csv***

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

6.5.5 spatial folder

The spatial folder contains a single file, *regions_gcs.js*. This is a spatial file in the JSON format; it has the appropriate study area and regions for the assessment. This file will be created by the OHI team for all regional assessments.

6.5.6 *calculate_scores.r*

`calculate_scores.r` will run the Toolbox calculations 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*.

6.5.7 scores.csv

`scores.csv` is a record of the calculated scores for the assessment (Global 2013 scores). Scores are reported for each dimension (future, pressures, resilience, score, status, trend) for each reporting region, and are presented in 'long' format.

6.5.8 Relaunching the Toolbox

After the initial Toolbox setup, further launches of the Toolbox Application 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.

7 Using the Toolbox for a Regional Assessment

** **Note: this page is under development**

This page explains how to incorporate all of the pre-Toolbox decisions your team has made for your regional assessment into the OHI framework and your repository. Having a good understanding of how the Toolbox is structured can also help identify what must be modified for a regional assessment, particularly with data and models. This page assumes a good understanding of the Toolbox file system.

The most common modifications you will make to your repository are changes with:

- updating or adding new data layers
- modifying goal models
- removing goals

7.1 Modifying and creating data layers

To modify existing or create new data layers, data must be appropriately formatted.

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

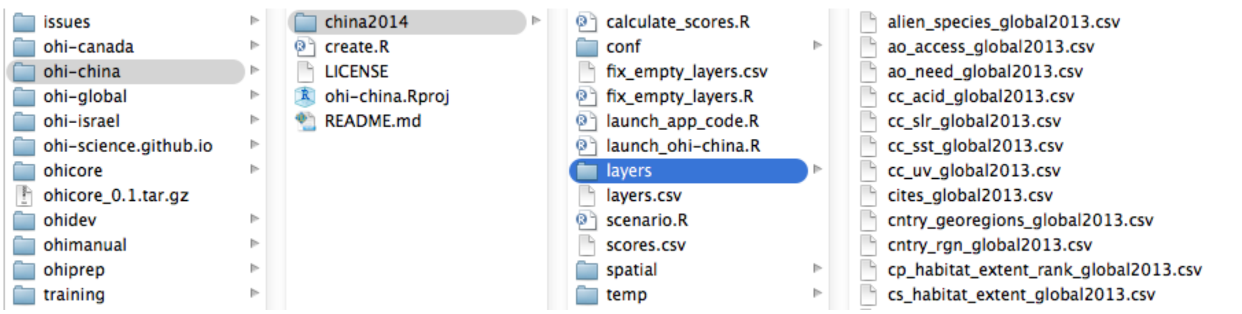
1. Create data layer with proper formatting
2. Save the layer in the `layers` folder
3. Register the layer in `layers.csv`
4. Check (and update when appropriate) `pressures_matrix.csv` and `resilience_matrix.csv` (located in the `ohi-[assessment]/[scenario]/conf` folder)

7.1.1 Create data layers with proper formatting

develop

7.1.2 Save data layers in the *layers* folder

Data layers are *.csv* files and are located in the `ohi-[assessment]/[scenario]/layers` folder. The layers provided in your regional assessment repo are the global values from the 2013 assessment: these layers all have a suffix of `_global2013.csv`. These data are at coarse-resolution and should be exhanged for local, high-resolution data when possible.



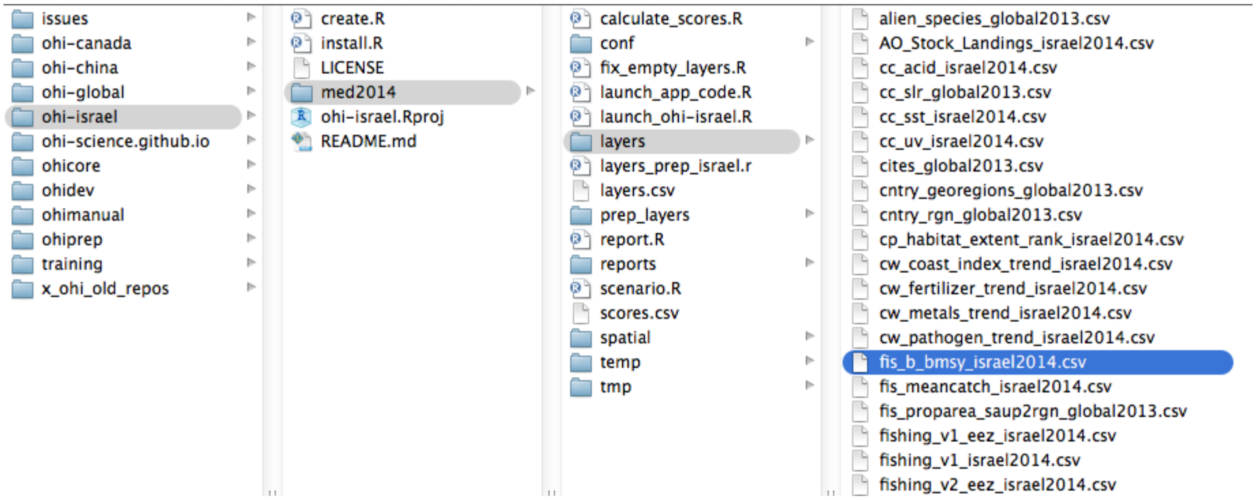
When you modify existing or create new data layers, we recommend saving this as a new *.csv* file with a suffix identifying your regional assessment (example: `_israel2014.csv`). Modifying the layer name provides an easy way to track which data layers have been updated regionally, and which rely on global data.

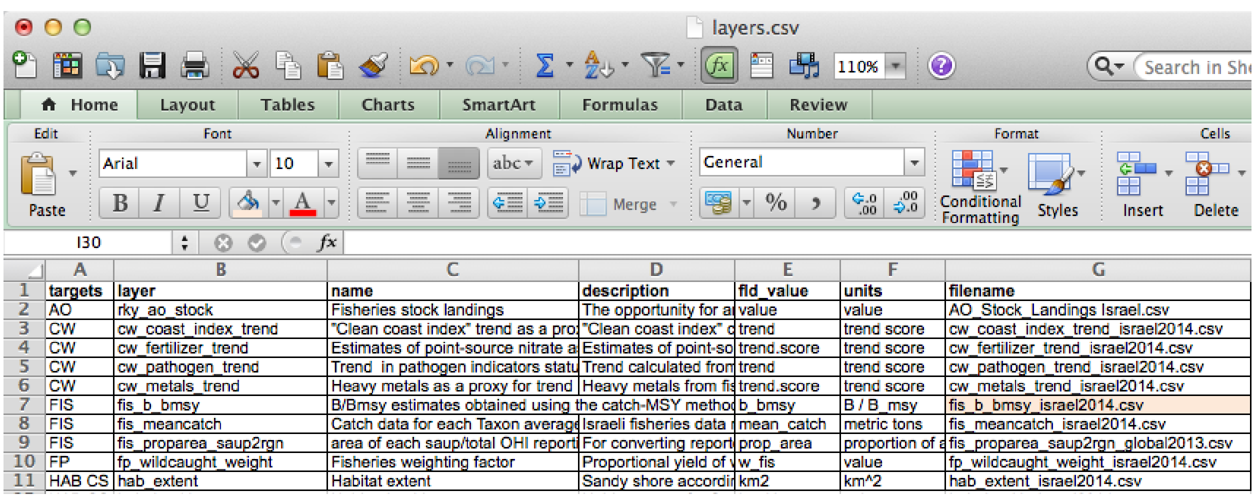
7.1.3 Register data layers in *layers.csv*

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

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 App as it confirms data formatting and content:

- **targets:** Add the 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.





targets	layer	name	description	fld_value	units	filename
AO	rky_ao_stock	Fisheries stock landings	The opportunity for a	value	value	AO_Stock_Landings Israel.csv
CW	cw_coast_index_trend	"Clean coast index" trend as a pro	"Clean coast index" c	trend	trend score	cw_coast_index_trend_israel2014.csv
CW	cw_fertilizer_trend	Estimates of point-source nitrate a	Estimates of point-so	trend.score	trend score	cw_fertilizer_trend_israel2014.csv
CW	cw_pathogen_trend	Trend in pathogen indicators statu	Trend calculated fron	trend	trend score	cw_pathogen_trend_israel2014.csv
CW	cw_metals_trend	Heavy metals as a proxy for trend	Heavy metals from fis	trend.score	trend score	cw_metals_trend_israel2014.csv
FIS	fis_b_bmsy	B/Bmsy estimates obtained using the catch-MSY metho		b_bmsy	B / B_msy	fis_b_bmsy_israel2014.csv
FIS	fis_meancatch	Catch data for each Taxon average	Israeli fisheries data	mean_catch	metric tons	fis_meancatch_israel2014.csv
FIS	fis_proparea_saup2rgn	area of each saup/total OHI reporti	For converting reporti	prop_area	proportion of a	fis_proparea_saup2rgn_global2013.csv
FP	fp_wildcaught_weight	Fisheries weighting factor	Proportional yield of v	w_fis	value	fp_wildcaught_weight_israel2014.csv
HAB CS	hab_extent	Habitat extent	Sandy shore accordi	km2	km^2	hab_extent_israel2014.csv

- **name:** Add a longer title for the data layer: this will be displayed in the Toolbox interface.
- **description:** Add a longer description of the new data layer this will be displayed in the Toolbox interface.
- **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

under development

7.2 Modifying goal models

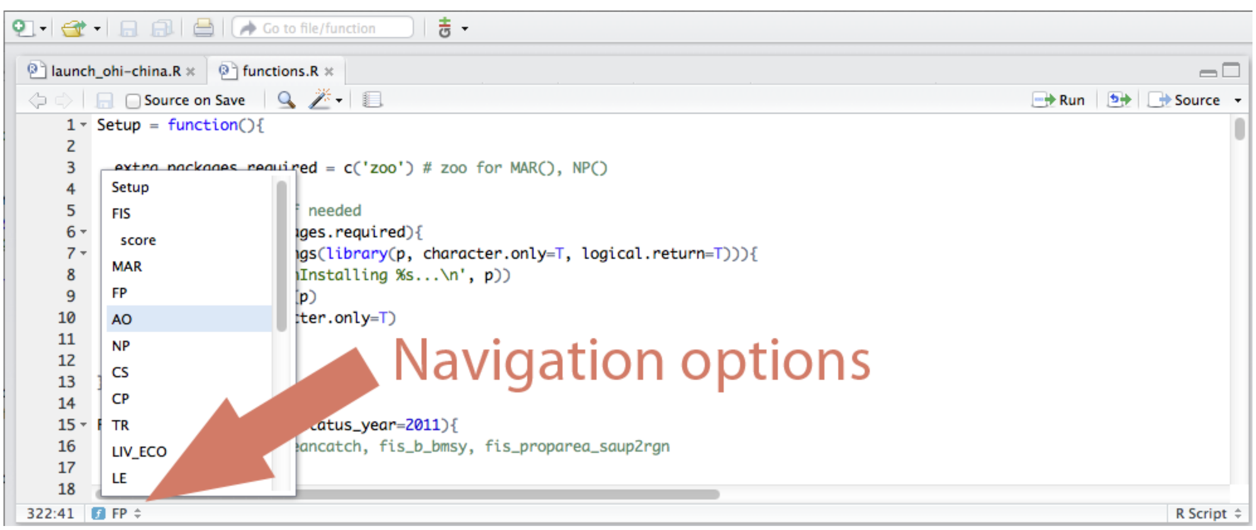
In the discussion on data layers above, when an existing layer is still used as before but has a new *filename*, nothing further needs to be done for the Toolbox to incorporate this updated layer. However, if a new layer has been added to the `layers` folder and registered in `layers.csv` (and potentially added to the pressures or resilience matrices), the Toolbox will still not use it unless it is incorporated into a goal model.

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

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

7.2.1 Update *functions.r*

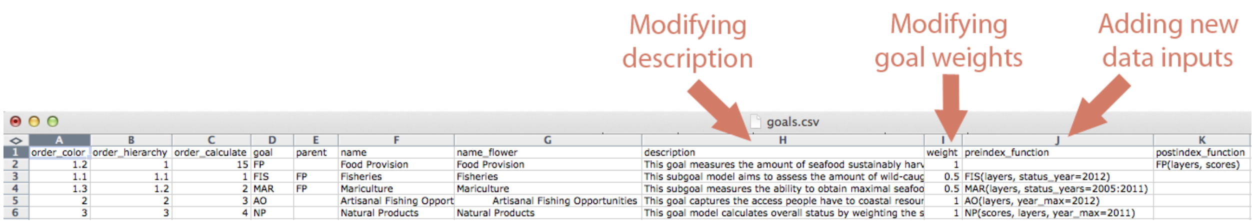
To incorporate a new data layer into a goal model, open `functions.R`: this script contains all the models for each goal and sub-goal. In RStudio, there is a navigation pane that can be used to navigate between them:



7.2.2 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 in the Toolbox Application.

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 percentage of the goal totals. `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).



	A	B	C	D	E	F	G	H	I	J	K
1	order_color	order_hierarchy	order_calculate	goal	parent	name	name_flower	description	weight	preindex_function	postindex_function
2	1.2	1	15	FP		Food Provision	Food Provision	This goal measures the amount of seafood sustainably harv	1		FP(layers, scores)
3	1.1	1.1	1	FIS	FP	Fisheries	Fisheries	This subgoal model aims to assess the amount of wild-caug	0.5	FIS(layers, status_year=2012)	
4	1.3	1.2	2	MAR	FP	Mariculture	Mariculture	This subgoal measures the ability to obtain maximal seafoo	0.5	MAR(layers, status_years=2005:2011)	
5	2	2	3	AO		Artisanal Fishing Opport	Artisanal Fishing Opportunities	This goal captures the access people have to coastal resour	1	AO(layers, year_max=2012)	
6	3	3	4	NP		Natural Products	Natural Products	This goal model calculates overall status by weighting the s	1	NP(scores, layers, year_max=2011)	

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

- check the years
- etc. . .

7.3 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:

1. `functions.r`
2. `goals.csv`
3. `pressures_matrix.csv`
4. `resilience_matrix.csv`

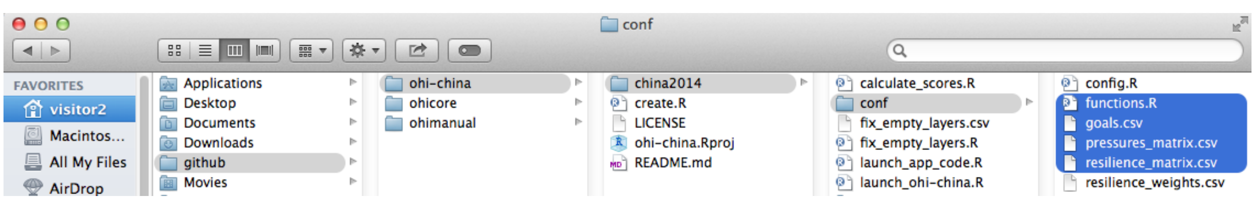
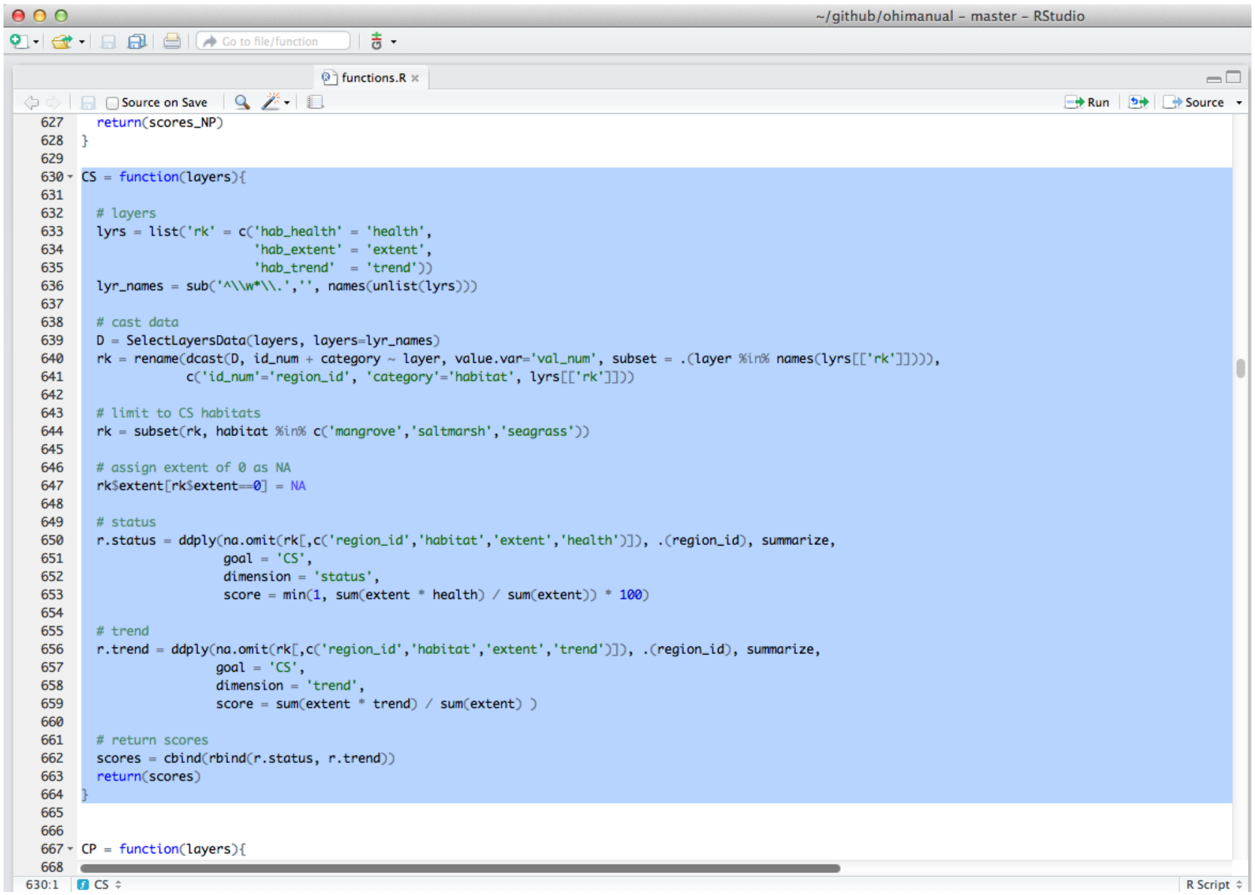


Figure 3: *Failing to delete all referenced layers after the goal is deleted will prompt a number of error messages.*

7.3.1 Example: Removing 'Carbon Storage' goal

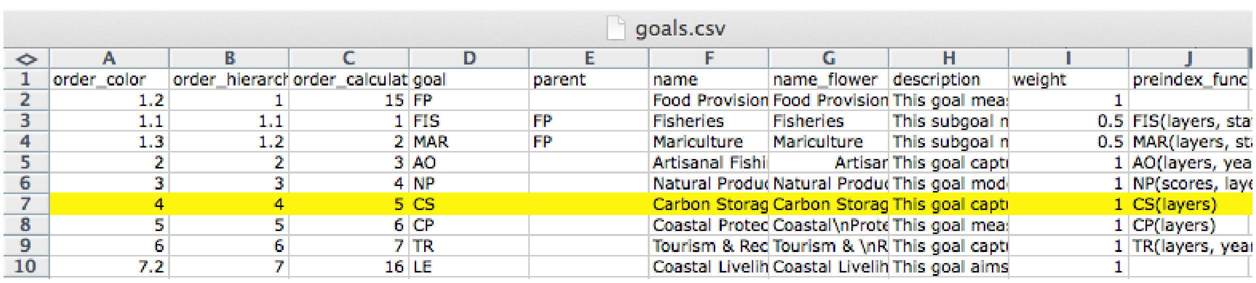
1) Remove the CS goal model from `functions.r`:

2) Remove the CS row from `goals.csv`:



```r
  return(scores_NP)
}

CS = function(layers){

  # layers
  lyrs = list('rk' = c('hab_health' = 'health',
                       'hab_extent' = 'extent',
                       'hab_trend'  = 'trend'))
  lyr_names = sub('^\\w*\\.','', names(unlist(lyrs)))

  # cast data
  D = SelectLayersData(layers, layers=lyr_names)
  rk = rename(dcast(D, id_num + category ~ layer, value.var='val_num', subset = .(layer %in% names(lyrs[['rk']]))),
              c('id_num'='region_id', 'category'='habitat', lyrs[['rk']]))

  # limit to CS habitats
  rk = subset(rk, habitat %in% c('mangrove','saltmarsh','seagrass'))

  # assign extent of 0 as NA
  rk$extent[rk$extent==0] = NA

  # status
  r.status = ddply(na.omit(rk[,c('region_id','habitat','extent','health')]), .(region_id), summarize,
                   goal = 'CS',
                   dimension = 'status',
                   score = min(1, sum(extent * health) / sum(extent)) * 100)

  # trend
  r.trend = ddply(na.omit(rk[,c('region_id','habitat','extent','trend')]), .(region_id), summarize,
                  goal = 'CS',
                  dimension = 'trend',
                  score = sum(extent * trend) / sum(extent) )

  # return scores
  scores = cbind(rbind(r.status, r.trend))
  return(scores)
}


CP = function(layers){
```

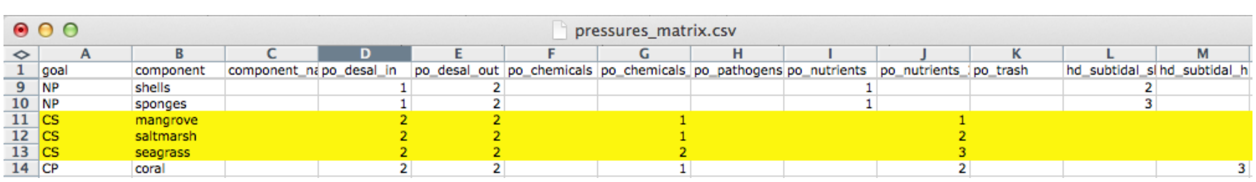
Figure 4: Delete the highlighted text that references the CS layers and calculates CS goal status, trend, and scores



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 captu	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 captu	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 captu	1	TR(layers, yea
10	7.2	7	16	LE		Coastal Livelih	Coastal Livelih	This goal aims	1	

Figure 5: Delete the highlighted row that contains the CS goal



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 6: Delete the highlighted rows that contain CS pressures

3) Remove all CS rows from `pressures_matrix.csv`:

4) Remove all CS rows from `resilience_matrix.csv`:

resilience_matrix.csv

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	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
7	SPP		alien_species	cites			fishing_v2_eez					habitat_combo_eez	
8	CS										habitat_combo		
9	CS	mangrove only									habitat_combo		
10	CW												
11	FIS						fishing_v2_eez					habitat_combo_eez	

Figure 7: Delete the highlighted rows that contain CS resilience

7.4 Example modifications

7.4.1 Adding a new layer to a goal model

In this example we will walk through the following steps:

1. decide to add artisanal access component to the model because of locally available data
2. prepare the data file; save layer ao_access_art
3. register in `layers.csv`
4. update goal model in `functions.r`
5. update goal call in `goals.csv`

1) and 2) is done outside of the Toolbox

3. register in `layers.csv`

Sheets | Charts | SmartArt Graphics | WordArt

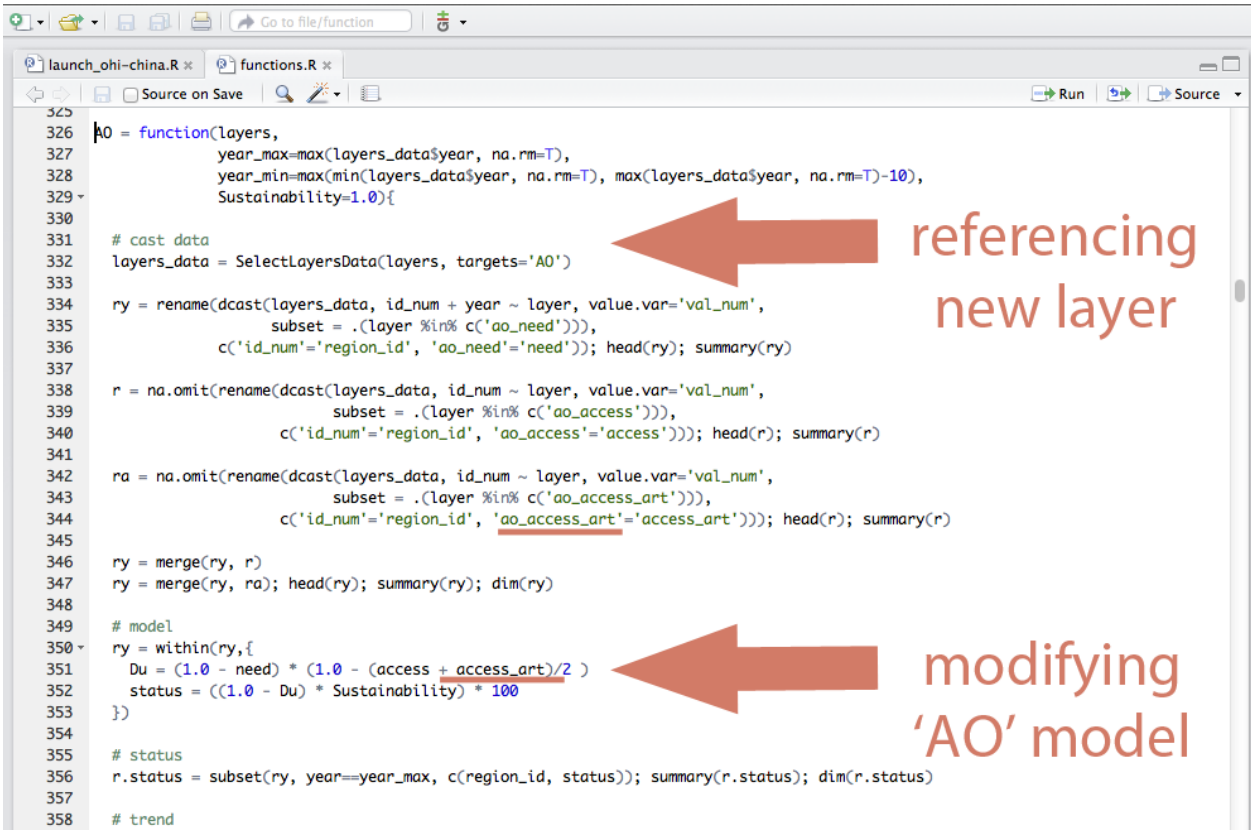
	A	B	C	D	E	F	G	H
1	targets	layer	name	description	fld_value	units	filename	fld_id_num
2	AO	ao_access	Fisheries manageme	The opportunity f	value	value	ao_access_china2014.csv	rgn_id
3	AO	ao_access_art	Example data	Made-up data	value	value	ao_access_art_china2014.csv	rgn_id
4	AO	ao_need	Purchasing power p	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
6	CW	cw_fertilizer_trend	Fertilizer consumpti	Statistics on fertil	trend score	trend score	cw_fertilizer_trend_global2013.csv	rgn_id

4. update goal model

5. develop

7.5 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 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: 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 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.

8.12 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?

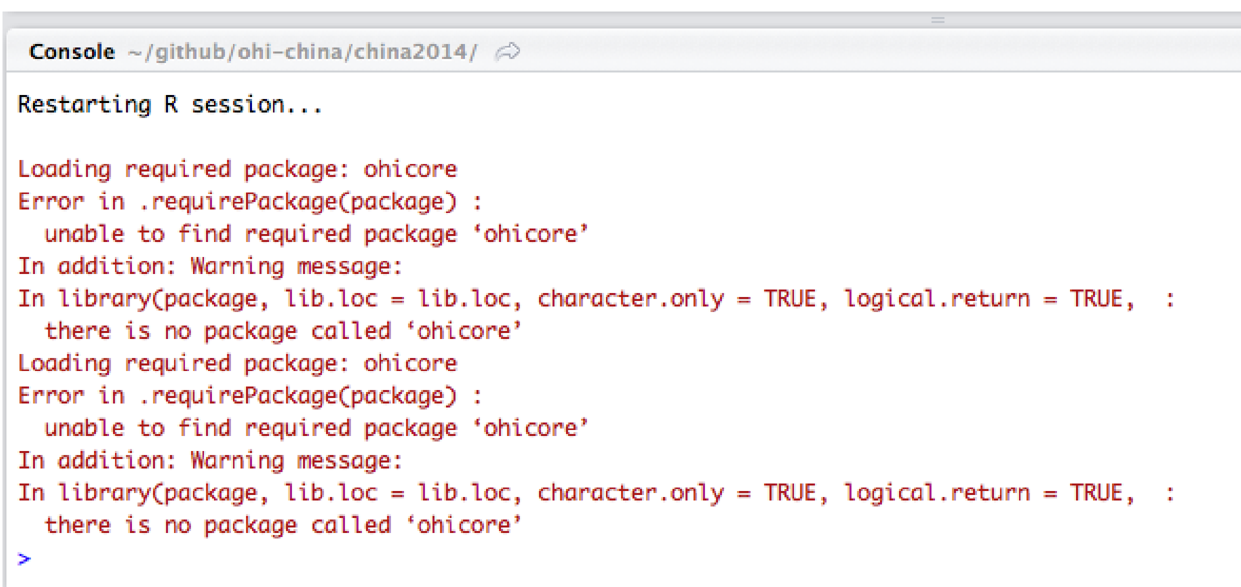
A: Commercial high and low bycatch are categorical values that were set based on fishing gear type. This began as a list of gear types used, producing a range of potential bycatch frequencies (from local reports when possible), which can be rescaled.

9 Toolbox Troubleshooting

The Toolbox prints messages during its processing to help guide error checking and debugging. Here are a few troubleshooting tips.
(** note: this page is under development).

9.1 Loading RWorkspace on Restart

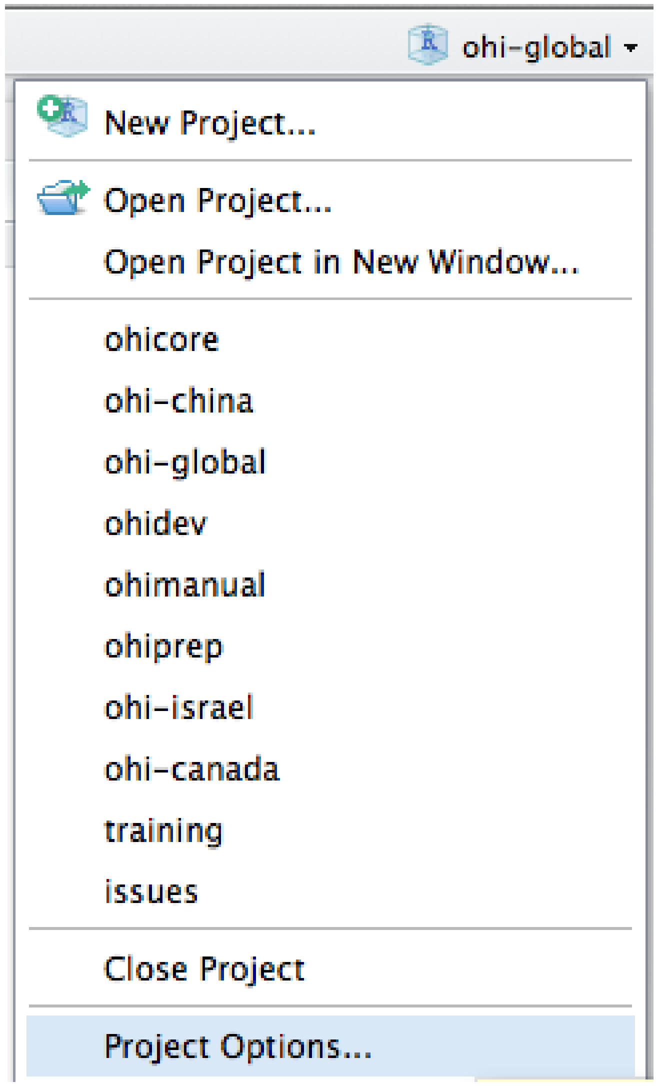
When you restart your R Session (Session > Restart R on a Mac), if you see that it is trying to load `ohicore`, it may give you an error:



```
Console ~/github/ohi-china/china2014/

Restarting R session...

Loading required package: ohicore
Error in .requirePackage(package) :
  unable to find required package 'ohicore'
In addition: Warning message:
In library(package, lib.loc = lib.loc, character.only = TRUE, logical.return = TRUE,  :
  there is no package called 'ohicore'
Loading required package: ohicore
Error in .requirePackage(package) :
  unable to find required package 'ohicore'
In addition: Warning message:
In library(package, lib.loc = lib.loc, character.only = TRUE, logical.return = TRUE,  :
  there is no package called 'ohicore'
>
```

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:

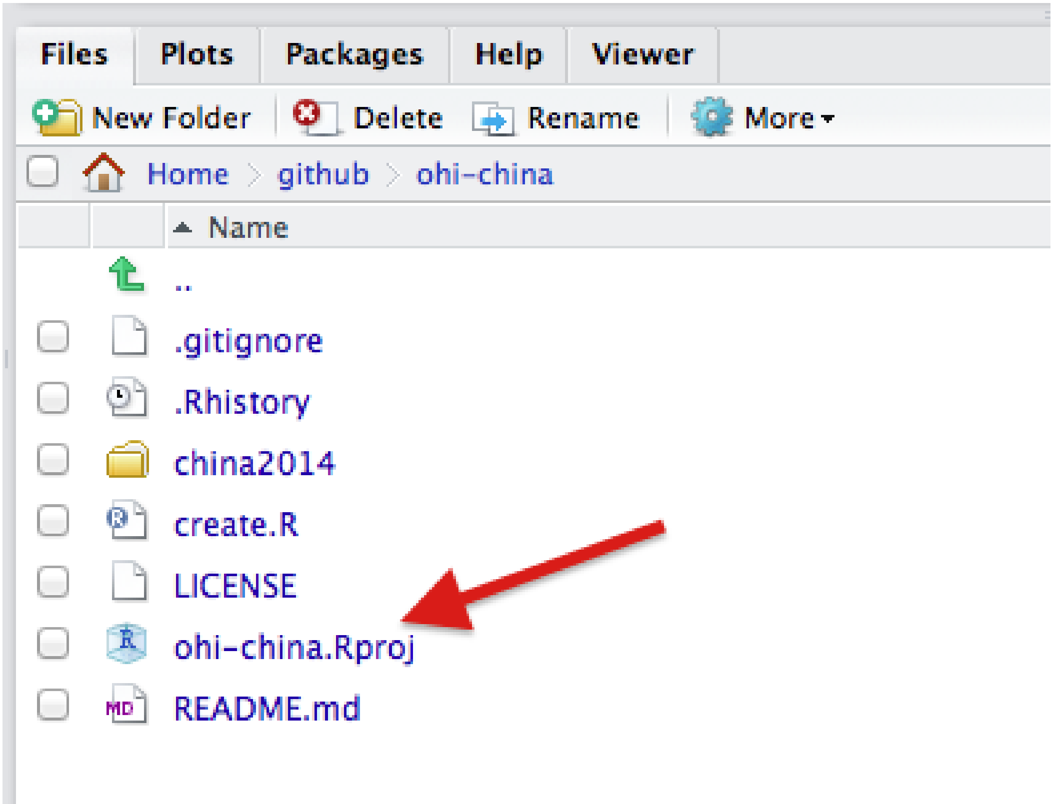


2. Change all options to **No:**

9.2 Calculating Pressures. . .

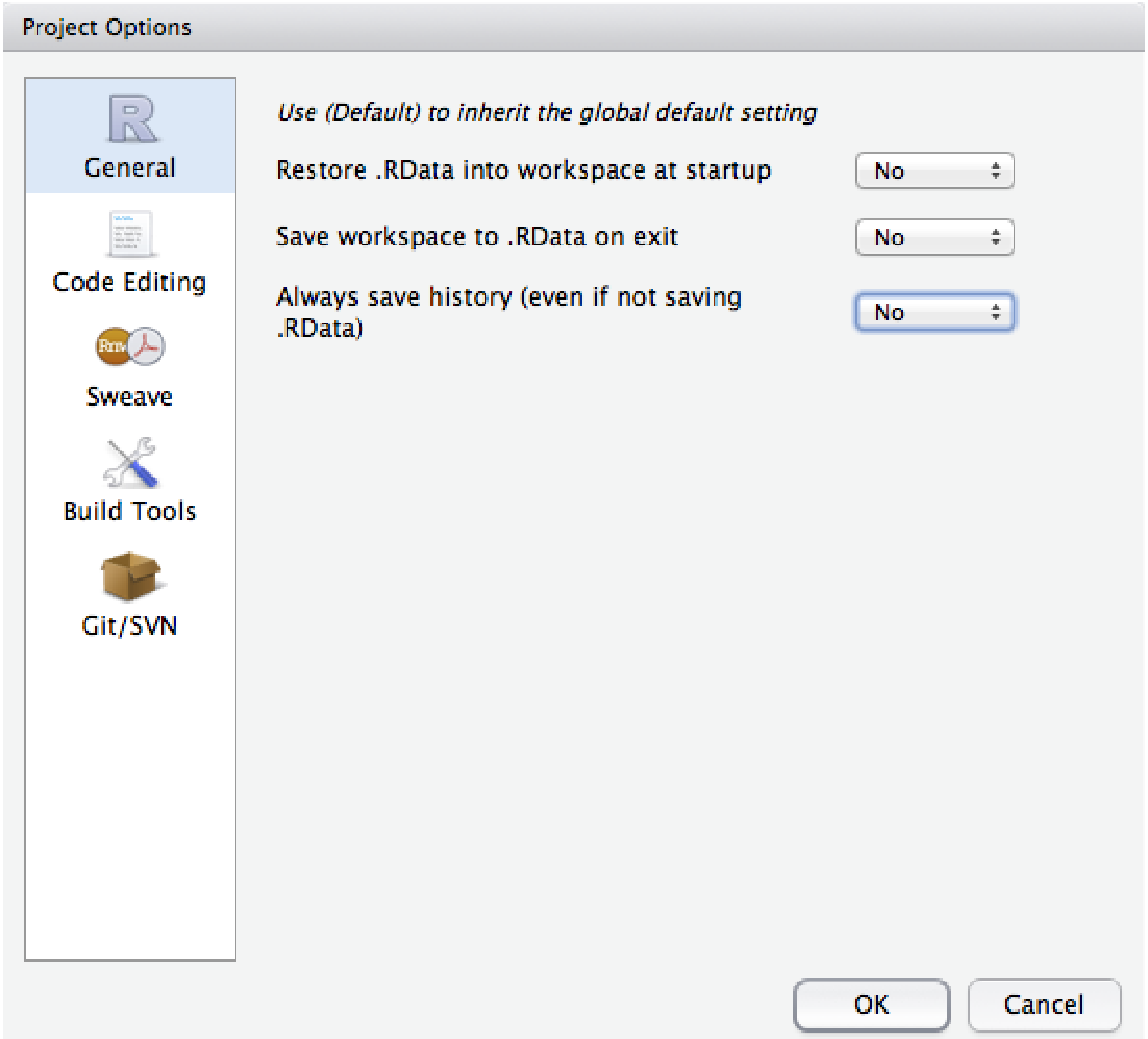
9.2.1 'The following components for [goal] are not in the aggregation layer [layer]. . . '

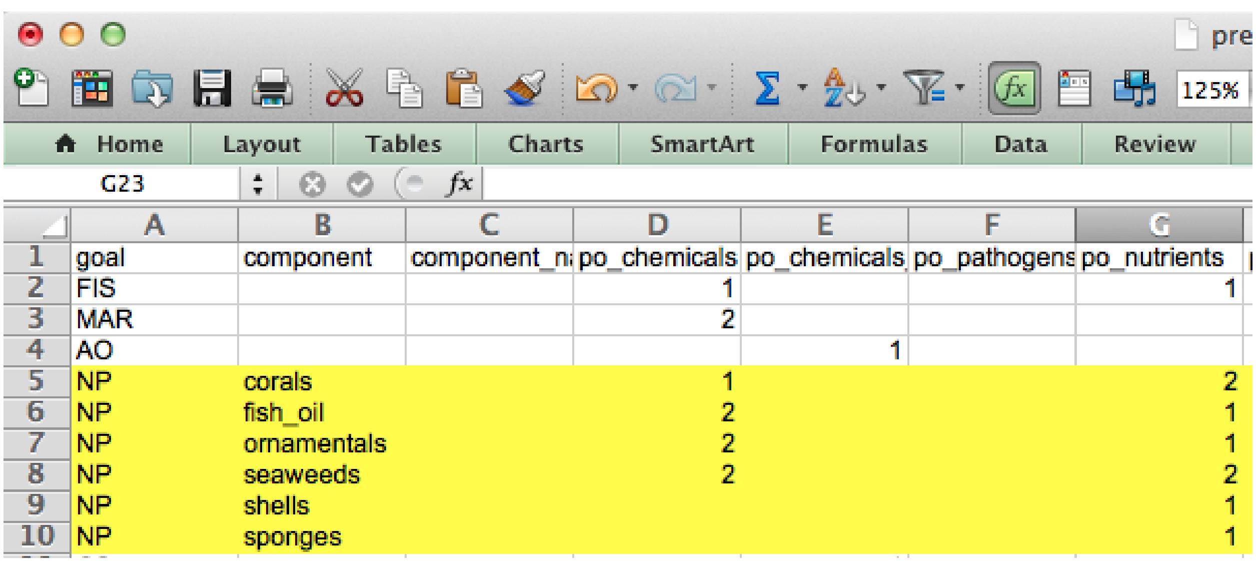
Example:




```
Running Setup()...
Calculating Pressures...
The following components for NP are not in the aggregation layer np_harvest_product_weight categories (
Error in data.frame(names(P), P) :
  arguments imply differing number of rows: 0, 1
```

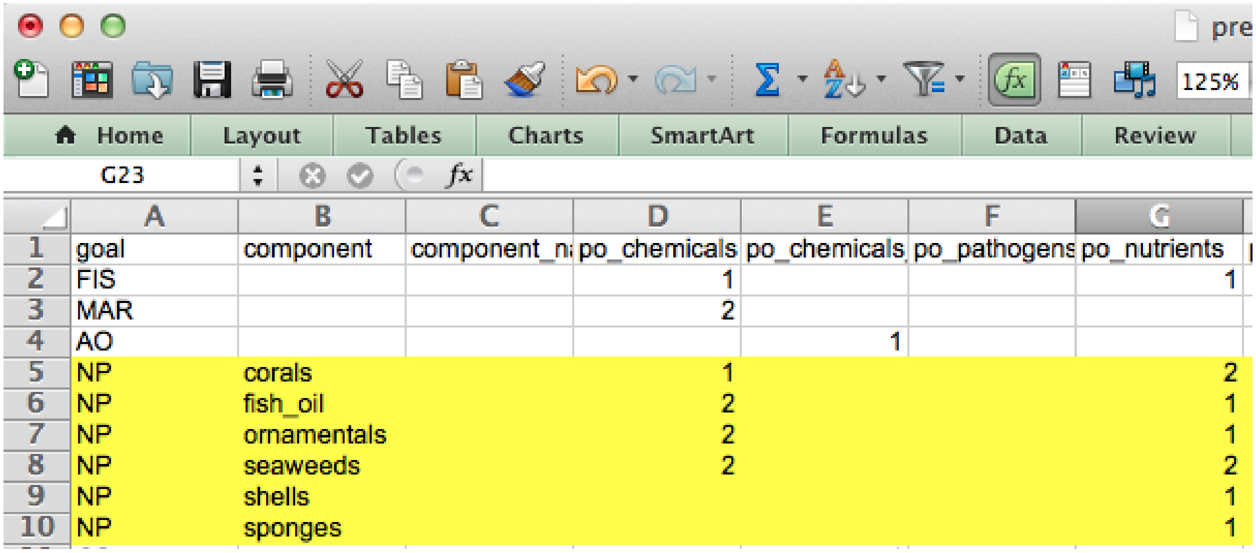
This error means you should update your pressures matrix because it expects there to be components that your region does not have.


Project Options
General
Code Editing
Sweave
Build Tools
Git/SVN
Use (Default) to inherit the global default setting
Restore .RData into workspace at startup
No
Save workspace to .RData on exit
No
Always save history (even if not saving .RData)
No
OK
Cancel


Home
Layout
Tables
Charts
SmartArt
Formulas
Data
Review
G23
125%
goal component component_n po_chemicals po_chemicals po_pathogens po_nutrients
FIS 1 1
MAR 2
AO 1
NP corals 1 2
NP fish_oil 2 1
NP ornamentals 2 1
NP seaweeds 2 2
NP shells 1
NP sponges 1

9.2.2 'Error in matrix...'

Example: >

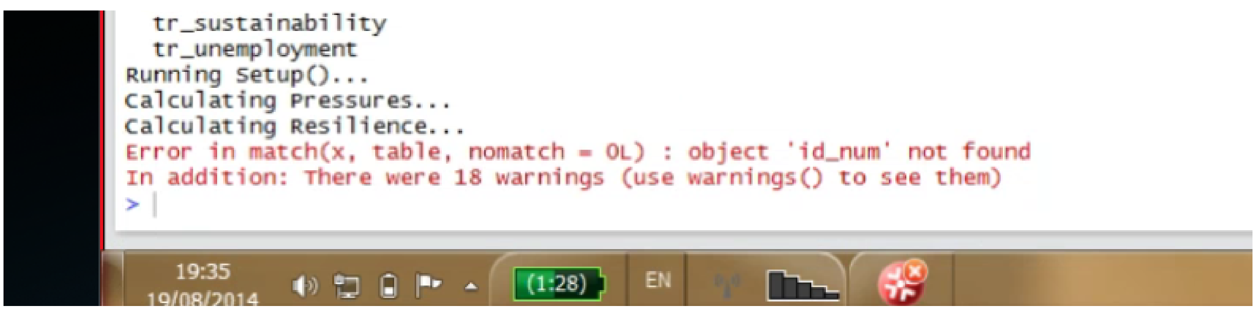


	A	B	C	D	E	F	G
1	goal	component	component_n	po_chemicals	po_chemicals	po_pathogens	po_nutrients
2	FIS			1			1
3	MAR			2			
4	AO				1		
5	NP	corals		1			2
6	NP	fish_oil		2			1
7	NP	ornamentals		2			1
8	NP	seaweeds		2			2
9	NP	shells					1
10	NP	sponges					1

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

9.3 Calculating Resilience ...

9.3.1 '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`.