Proceedings of the Interactive Tools for Science Advice Workshop Series in Maritimes Region, November-December, 2019

Catalina Gomez, Jessica Sameoto, Freya Keyser, Paul Regular, Lindsay Beazley, Chantelle Layton, Clark Richards, Ryan Stanley, Jamie Tam, Kiyomi Ferguson, Peter Kraska

Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

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PROCEEDINGS OF THE INTERACTIVE TOOLS FOR SCIENCE ADVICE WORKSHOP SERIES IN MARITIMES REGION, NOVEMBER-DECEMBER, 2019

by

Catalina Gomez[1], Jessica Sameoto[1], Freya Keyser[1], Paul Regular[2], Lindsay Beazley[1], Chantelle Layton[1], Clark Richards[1], Ryan Stanley[1], Jamie Tam[1], Kiyomi Ferguson[1], Peter Kraska[3]

[1]Bedford Institute of Oceanography
1 Challenger Drive
PO Box 1006
Dartmouth, NS
B2Y 4A2

[2]Northwest Atlantic Fisheries Centre
St. John's, Newfoundland and Labrador
A1C 5X1

[3]St. Andrews Biological Station
125 Marine Drive
Saint Andrews, New Brunswick
E5B OE4

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Open, reproducible, and collaborative science requires the development of tools that can analyze, visualize, and update data. Interactive based tools have the potential to transform the way scientific results are communicated, giving the audience more control over the exploration of data inputs and outputs, thus permitting an engaged and detailed exploration of patterns otherwise obscured by traditional static approaches (e.g., figures, tables, and reports). In the DFO Science community, R (R Core Team 2019) has become one of the most popular programming languages used for statistical computing, graphics and automated generation of scientific reports. Available packages for building interactive visualizations in R (e.g., flexdashboard, shiny, and plotly) have provided the ability to move towards more open data products and reporting. These proceedings summarize a series of R Learning and Development workshops on the use of interactive tools for science advice hosted by the Fisheries and Ocean Canada (DFO) Science Sector (Maritimes Region) in Fall 2019. These workshops enabled Science staff to share and learn about the application of interactive tools and their role in supporting a more open approach for science communication and advice. It is hoped that discussions from these workshops will initiate a path-forward to extend interactive tools to other approaches at DFO. These proceedings provide an overall summary of this R Learning and Development series, describing the materials, presentations, questions, discussions, and ultimately recommendations on how to continue exploring tools to improve science communication and advice.

RÉSUMÉ

Gomez, C., Sameoto, J.A., Keyser, F., Regular, P., Beazley, L., Layton, C., Richards, C., Stanley, R., Tam, J., Ferguson, K., Kraska, P. 2020. Proceedings of the Interactive Tools for Science Advice Workshop Series in Maritimes Region, November-December, 2019. Can. Tech. Rep. Aquat. Sci. 3369: v + 20 p.

La science ouverte, reproductible et collaborative nécessite le développement d'outils permettant d'analyser, de visualiser et de mettre à jour les données. Les outils interactifs ont le potentiel de transformer la manière dont les résultats scientifiques sont communiqués, en donnant au public un plus grand contrôle sur l'exploration des données d'entrée et de sortie, permettant ainsi une exploration interactive et détaillée des modèles autrement obscurcis par les approches statiques traditionnelles (par exemple, les figures, les tableaux et les rapports). Dans la communauté scientifique du MPO, R est devenu l'un des langages de programmation les plus populaires utilisés pour le calcul statistique, les graphiques et la production automatisée de rapports scientifiques. Les logiciels disponibles pour créer des visualisations interactives en R ont permis d'évoluer vers des produits de données et des rapports plus ouverts. Le présent compte rendu résume une série d'ateliers d'apprentissage et de développement de R sur l'utilisation d'outils interactifs pour les avis scientifiques, organisés par le Secteur des sciences du ministère des Pêches et des Océans (MPO) (Région des Maritimes) à l'automne 2019. Ces ateliers ont permis au personnel scientifique de partager et d'apprendre sur l'application des outils interactifs et leur rôle dans le soutien d'une approche plus ouverte pour la communication et les avis scientifiques. Nous espérons que les discussions découlant de ces ateliers ouvriront la voie à la mise en place d'outils interactifs pour d'autres approches au sein du MPO. Le présent compte rendu constitue un résumé général de cette série d'apprentissage et de perfectionnement en R, décrivant le matériel, les présentations, les questions, les discussions et, finalement, les recommandations sur la façon de continuer à explorer les outils permettant d'améliorer la communication et les avis scientifiques.

INTRODUCTION

Open, reproducible, and collaborative science at DFO involves the development of tools to analyze, visualize, and update data in an efficient and cost-effective manner. Increasingly, advice provision and ocean management requires the integration and analysis of large and diverse data sets, with outputs being used to inform decision-making processes such as stock assessment, ecosystem approaches to fisheries management, conservation planning, and marine spatial planning. Efforts are underway to develop tools for transparent, traceable, and transferable assessments at DFO (Edwards et al. 2018), which combined with interactive spatial tools, demonstrate a new and powerful approach for science communication and advice (Regular et al. submitted). Interactive tools allow the audience to interact with data and data products, allowing increased control over what type of information the user wants to explore in more detail over traditional static outputs (e.g., tables, figures, reports). For instance, Gomez et al. (2016) used an interactive interface (published as a supplement: https://catalinagomez.shinyapps.io/BRSApp/) that allowed users to review and manipulate information gathered on the behavioural responses of wild marine mammals to noise, and the disparity between science and policy. This interactive tool allows readers to download, filter, and re-plot the data in a variety of ways to further explore and understand this work in a more open and transparent manner.

Interactive tools offer a tangible step towards more open-data science and regulatory advice, and have recently been developed within DFO to enrich scientific review and advisory processes such as those coordinated by the Canadian Science Advisory Secretariat (CSAS). For instance, in 2017 the DFO Maritimes Region developed a tool (https://incorporatingecosystemapproach.shinyapps.io/indiapp/) for an exploratory ecosystem-focused analysis that integrates information derived from oceanographic conditions and ecological indicators, together with stock indices. The primary aim of this project was to provide an initial exploration of how interactive tools can enrich and/or augment stock assessments, and was used for discussion at the Groundfish CSAS Update on December 4-5, 2017. Such a tool has allowed end users to actively explore data inputs and outputs, in addition to the commonly used static plots. Regular et al. (submitted) provide an example of this progress within DFO, by building interactive visualizations using new open source R packages (Flexdashboard, Shiny, and Plotly; Allaire 2017, Chang et al. 2019, and Sievert 2018, respectively) directly into stock assessment processes. Regular et al. (submitted) contend that the use of interactive visualization tools as part of the science advice process can lead to improved transparency, engagement, and communication, between all participants in the peer-review process. Another example is the open knowledge platform e-Drivers (https://david-beauchesne.shinyapps.io/edriversapp/) developed by David Beauchesne to facilitate the process of gathering experts committed to structuring, standardizing, and sharing

knowledge on drivers in support of science and management (https://david-beauchesne.shinyapps.io/edriversapp/)

Recognizing the benefits and relative simplicity of developing R interactive tools, a series of R Learning and Development sessions were held to: introduce these new approaches to the broader DFO Science community; to share and learn about the use of interactive tools and their role in improving the way we explore, communicate, and provide science advice; and to kick start a network of users interested in extending these approaches to other science applications beyond stock assessment. These proceedings provide an overall summary of this series on the use of Interactive Tools for Science Advice hosted by DFO Science Sector – Maritimes Region, in November and December, 2019.

This series of Learning and Development training consisted of three R workshop components:

i) An introduction to R Shiny Applications,

ii) Hands-on training on Interactive Tools for Science Advice (e.g. flexdashboard R package, Allaire 2017), and

iii) Interactive tools for science advice with R dashboard.

The first and third series were open to everyone in the DFO Maritimes Region interested in R (WebEx capabilities were available), while the second workshop was attended by a total of 28 Maritimes Region Science Staff from all Science Divisions, and one participant from the Oceans Management Program. The intent of these proceedings is to document the discussion and material from this workshop series and provide an open platform for which other interested users can download and try the learned approaches (including R code). Further, we propose recommendations on how to move forward with these types of novel approaches that challenge traditional ways of pursuing science advice.

OVERVIEW OF R LEARNING AND DEVELOPMENT SERIES

Foreword: Towards Climate Change Neutrality

Learning and Development is fundamental to effective networking, reporting recent findings, and implementing new tools available in the scientific realm. The DFO Maritimes Region Science Sector includes Learning and Development as part of its action plan to address the results of the 2018 Public Service Employee Survey. However, major hurdles to attaining the full benefits of Learning and Development include scheduling conflicts (missed opportunities) and an increasing carbon footprint (travel requirements). Fox et al. (2009) flagged the relatively large carbon footprint of scientists (conservation biologists)

compared to both American and global averages. Differences in per capita carbon production are primarily due to flying, in part, to participate in workshops and learning events. However, there are practical solutions to reducing carbon footprints when planning workshops and conferences (Bossdorf et al. 2009). This workshop series aimed to balance the need to keep up to date with learning and development requirements, while minimizing individual and departmental carbon footprints through the reduction of travel (i.e., air travel).

To make this R workshop series “greener”, we chose a local venue, avoided disposable tableware, did not print materials, used primarily electronic information, and invited primarily local participants based at the Bedford Institute of Oceanography (BIO). CO_2 emissions from the workshop were primarily attributed to air travel of the instructor from St. John’s, Newfoundland and Labrador. Maritimes Region also includes St. Andrews Biological Station (SABS) in New Brunswick. In the spirit of connecting initiatives from SABS and BIO, while keeping our goal to reduce our carbon footprint, we invited one participant from SABS in order to facilitate information transfer to its facility. Further, we recorded the seminar, documented all material, posted the workshop code online, and provided two additional series of virtual workshops that were remotely accessible through Webex. Recording the workshop material and making it available to others is a pragmatic solution to promoting carbon-neutrality in Learning and Development programs that requires no additional travel.

Our approach to minimize the carbon footprint associated with these workshops, while maintaining a high standard of science technical training was deemed successful and acknowledged by participants as an important consideration in planning future workshops. Ultimately hosting workshop materials online will help to improve individual and departmental workflow(s) essential to learning, teamwork, and career development.

Format

This series of R Learning and Development training on using interactive tools for science advice consisted of three components: i) an introduction on Shiny Applications: lunch and learn session, ii) a full-day hands-on workshop entitled ‘Interactive Tools for Science Advice’ followed by an open seminar delivered by Paul Regular (DFO Science, NFLD Region), and iii) an Interactive Tools for Science Advice dashboard: lunch and learn session (Table 1).

All material and code from these sessions is publically accessible through a repository for material related to regularly held R workshops at BIO: https://github.com/AtlanticR/bioRworkshops/. Specific details of each component are described in the following sections.

Table 1. R Learning and Development workshop series on Interactive Tools for Science Advice in Maritimes Region, November-December, 2019.

R Workshop Series Component	Duration	Leads	Location	Participants
Introduction to Shiny: Lunch-and-Learn Session*	1 hour (November 1, 2019)	Chantelle Layton and Clark Richards	BIO and WebEx	Open to everyone at BIO interested in R
Interactive Tools Workshop for Science Advice**	1.5 days (November 5 and 6, 2020)	Paul Regular	Northwest Atlantic Fisheries Organization (NAFO) headquarters	29 participants invited
Interactive Tools for Science Advice dashboard: Lunch-and-Learn Session**	1 hour (December 6, 2019)	Paul Regular, Catalina Gomez, Peter Kraska	BIO and WebEx	Open to everyone at BIO interested in R

*https://github.com/AtlanticR/bioRworkshops/tree/master/14_Shiny_intro
**https://github.com/AtlanticR/bioRworkshops/tree/master/16_ToolsScienceAdvice

I: INTRO TO SHINY: LUNCH-AND-LEARN SESSION 1

Chantelle Layton and Clark Richards, November 1, 2019 at BIO

This workshop was delivered as part of the BIO lunch-and-learn R workshops. Shiny is an open source R package that provides a framework to build interactive web applications without requiring HTML, CSS, or JavaScript knowledge. It uses two essential elements: a user interface (i.e., 'ui'), and a server, which contains the code for the app (https://shiny.rstudio.com). As mentioned in the preface, R Shiny web applications are increasingly being used to explore research interactively. This workshop provided an introduction on how to build a Shiny app (Table 1). During this workshop we also explored Shiny applications that have been developed by Chantelle Layton and Clark Richards at BIO demonstrating BIO glider missions, real-time location and data collections, and the Arctic observatory. As part of this workshop, a brief survey was circulated to all Science staff in the Maritimes Region to help inventory the current extent of Shiny applications to date (Table 2). The hope is that this list will expand after this learning and development series.

Table 2. R Interactive Tools available in Maritimes Region as of January 2020.

Description	Shiny App	Code Access
Past mission of BIO gliders	https://noise.phys.ocean.dal.ca/barrow/missionsMap/	https://github.com/DFOglider/missionsMap
Location and data of BIO gliders in real-time	https://noise.phys.ocean.dal.ca/barrow/pilotingApp/	https://github.com/DFOglider/pilotingApp
Arctic observatory	https://noise.phys.ocean.dal.ca/barrow/bsrto/	
Explore impacts of noise on behaviour of marine mammals	https://catalinagomez.shinyapps.io/BRSApp/	https://github.com/gomezcatalina/BRS_SB
Exploratory ecosystem focused analysis that integrates information derived from oceanographic conditions and ecological indicators, together with stock indices	https://incorporatingecosystemapproach.shinyapps.io/indiapp/	
Interactively explore various bloom fitting methods for pre-defined boxes in the north Atlantic using satellite derived chlorophyll-a measurements	not hosted	https://github.com/clayton33/bloomFitApp
Interactive tool for exploring and QCing any and all data - facilitates comparison of variables by allowing user to choose x and y axes, as well as field to facet by. Individual data points can be flagged with comments	not hosted ("Mar.JoyofQC")	https://github.com/Maritimes/Mar.JoyofQC/
Reads ODF files then allows the user to change the quality flags for suspect points	visual QC app in development	https://github.com/Xandac/visual_qc_editor
Purpose is to report latest right whale observation for dynamic spatial management purposes. Hosted by Dal, partnership with DFO.	https://whalemap.ocean.dal.ca/	

II: INTERACTIVE TOOLS FOR SCIENCE ADVICE: WORKSHOP AND SEMINAR

Paul Regular, DFO, Newfoundland and Labrador Region, November 5 and 6, 2019 at BIO

This workshop was divided into four sessions (the full workshop agenda can be found in Appendix 1). The first three sessions were held November 5, 2019, at the Northwest Atlantic Fisheries Organization (NAFO) headquarters in Dartmouth, Nova Scotia, Canada and consisted of i) opening remarks, ii) a hands-on coding workshop, and iii) a discussion on the application of interactive tools within DFO Maritimes Region. These sessions brought together staff across different Maritimes Region Science divisions working on a wide variety of themes and research related to stock assessment, coral and sponges, whales, remote-sensing, oceanography, climate change, cumulative effects,

ecosystem indicators and modelling, Marine Protected Areas (MPA), and Marine Spatial Planning (Appendix 2). Following this hands-on training session, a seminar was delivered by Paul Regular at BIO on improving the communication and accessibility of stock assessment using interactive visualization tools. The following summarizes the proceedings of these four workshop sessions.

Day 1 – Session 1: Opening Remarks

Presenter: Lindsay Beazley

The idea for this workshop came from discussions between DFO Science staff that participated in the Pacific Region National Peer Review Process for Habitat Suitability Modelling Best Practices for Canada's Pacific Ocean, held June 11 and 12, 2019. Although participants were from varied divisions, it was realized that each participant faced similar challenges in effective communication and delivery of science advice related to spatial analysis and modelling. This highlighted an opportunity to continue to enhance the R Learning and Development series with the aim of improving efficiency across Science branch to advance habitat science under four themes (Figure 1):

- **Learn:** Learning and development: technical training
- **Connect:** Showcase local efforts and establish effective collaborations
- **Data:** Formalize and streamline spatial data requests and advice
- **Code:** Reproducible, reusable, and collaborative science

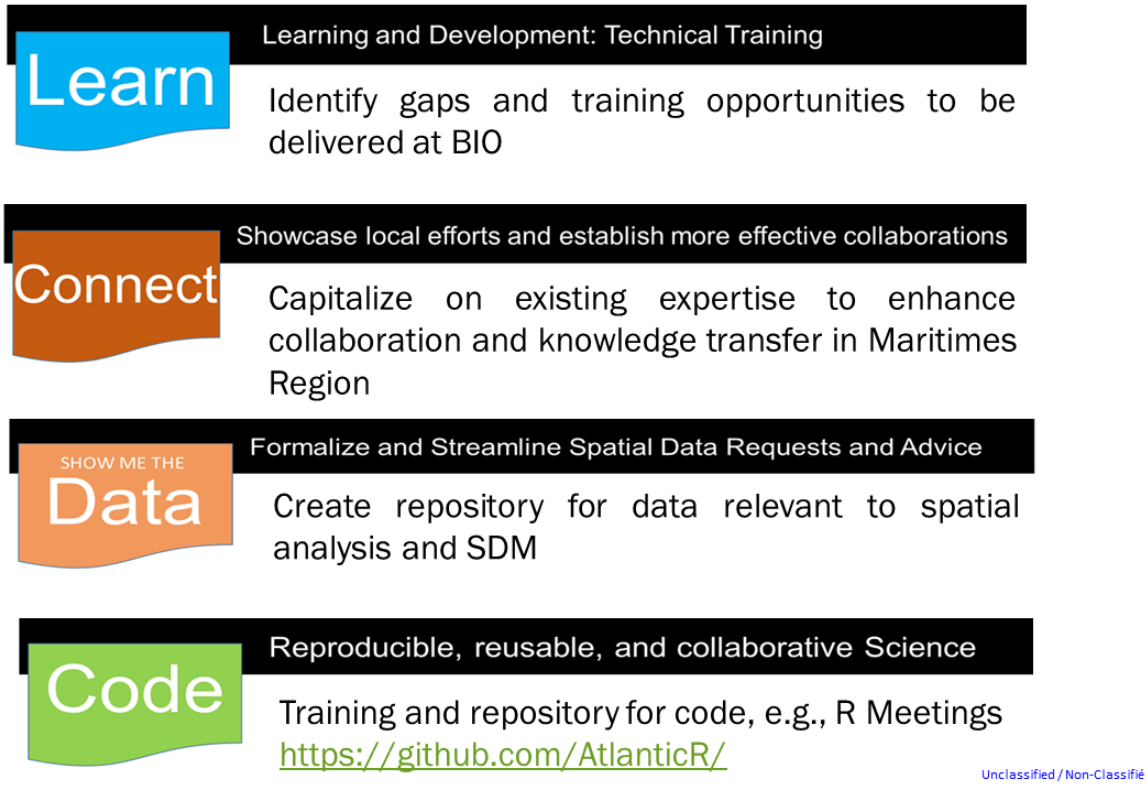

Figure 1. The 4 pillars of the Maritimes Region DFO R Learning and Development Series.

The workshop's organizing committee was composed of staff from different DFO Divisions: Catalina Gomez (Coastal Ecosystem Science Division: CESD), Jessica Sameoto (Population Ecology Division: PED), Freya Keyser (PED), Lindsay Beazley (Ocean Ecosystem Science Division: OESD), Javier Murillo-Perez (OESD), Kiyomi Ferguson (OESD) and Brad Hubley (PED). This committee drafted a Learning and Development proposal, supported by 27 staff in Maritimes Region, to host a workshop on the use of Interactive Tools for Science Advice. This proposal was approved and funded by the Science Branch Management Committee. The goal was to introduce and learn new methods that can be used to better communicate data/results as to maximize their understanding and uptake by colleagues and stakeholders. Paul Regular (DFO Science Newfoundland Region) was invited to deliver this workshop as he and his team have extensive experience using interactive tools to display and communicate science advice related to stock assessment.

Day 1 – Session 2: Stock assessment output dashboard in R and hands-on coding workshop

Presenter: Paul Regular

This is a summary of Paul Regular's hands-on workshop material. If you wish to directly cite this material please cite the source material (Regular et al. submitted).

Regular et al. (submitted) have used the Flexdashboard R package to develop a convenient way of bringing together a combination of information, plots, and tables to one self-contained html document. These browser-based thematic dashboards are built using R and are increasingly being adopted for data science (Matheus et al. 2018). Paul Regular led this hands-on workshop using a simplified skeleton R dashboard as a starting point. During his presentation he highlighted the following three packages:

- *Flexdashboard:* The flexdashboard R package[1] provides structure and containers where information will be placed (Allaire 2017). It uses R Markdown to render related images, figures, and texts into a dashboard-based interface. The dynamism of this dashboard is automatically transferred into display functionalities to zoom in and out, and to transfer to mobile-mode if the dashboard is visualized on mobile devices. The dashboard supports a wide range of components, including R base graphics, ggplot2 (Wickham 2016), gauges, tables, and html widgets such as plotly (Sievert 2018) and leaflet (Cheng et al. 2018). It can also use shiny (Chang et al. 2018) or crosstalk (Cheng et al. 2016) to bolster interactivity.

- *Plotly* (Sievert 2018)*:* This package supports the creation of interactive graphics, which are provided as examples in the skeleton R dashboard. The package allows the user to create interactive web graphics from ggplot2 (Wickham 2016) graphs. It also provides a more 'direct' link to the core plotly.js JavaScript library using syntax inspired by the grammar of graphics.

- *Crosstalk* (Cheng et al. 2016)*:* This package enables cross-widget interactions by linking, brushing, and/or filtering across multiple views. This means that interactions with one plot can affect changes in another plot within the flexdashboard interface. In this way, filters can be applied to two linked plots, tables or a combination of plots and tables that may be in the same or in different pages. This allows users to, for example, select/highlight one point in one plot and then be able to visualize the same point in a different plot. Crosstalk supports a wide range of htmlwidgets, such as plotly and leaflet.

[1] https://rmarkdown.rstudio.com/flexdashboard/

Paul Regular also delivered a presentation on Interactive Tools for Science Advice as part of the Technical Expertise in Stock Assessment (TESA) program. The recording of that webinar can be accessed on the TESA GCpedia site.

Day 1 – Session 3: Discussion on the application of Interactive tools within DFO Maritimes Region

Presentation Summary

This session started with three presentations to stimulate ideas and discussion. The first presentation was led by Chantelle Layton on the extensions of interactive tools for oceanographic data. She presented several examples of how R Shiny can be used for oceanographic data. Chantelle demonstrated the difference between Shiny and flexdashboard syntax, and highlighted the benefits of each approach and how they can be used together. Interactive tools could be used to share oceanographic data internally and externally. Publishing a tool that shows what data exist and what data are available would be a valuable first step towards improving data discoverability; progress has been made on this, but it is still under development. Discussion touched on which interactive tools (e.g., R Shiny versus flexdashboard) would be more appropriate for various applications based on their strengths and weaknesses. The flexdashboard approach, for example, can be quick and easy for any R user who has basic coding and R Markdown knowledge, whereas Shiny involves some more front-end coding and generally more technical knowledge of R, but it is perhaps more extensible.

The second presentation was led by Freya Keyser and Jessica Sameoto on extensions of interactive tools for spatial data. They summarized the various benefits of incorporating interactive tools into the communication of science advice, such as the potential for increased transparency, accessibility, and engagement with stakeholders. Interactive tools allow both subject experts and non-experts to learn more about an analysis, publication, or project since they can tailor their experience to their own interests (for example, focusing on a particular area or species). Some challenges were also noted: technical training and resource requirements, accessibility and long-term archiving, data privacy concerns, and ensuring that published interactive tools are both effective and accurate. An example from McHenry et al. (2019) was presented to demonstrate how an interactive tool can engage users with various levels of expertise, stimulate meaningful discussions, increase trust in results, and promote the development of new projects. In this example, habitat suitability hindcasts and projections for individual species by model type are presented in an R Shiny web application that can be explored interactively (https://heatherwelch.shinyapps.io/beyond_temperature/).

The third presentation was by Peter Kraska on exploring the infrastructure required to host interactive tools on a DFO server. Peter shared that DFO Maritimes Region now has an RStudio Server and a Shiny server running in the cloud provisioned by Information

Management and Technical Services (IMTS). At the time of the presentation these servers were not publically accessible. These servers allow computation in the cloud and may facilitate the sharing of interactive tools within DFO. User accounts are currently required and the Ocean Data Inventory Section (ODIS) is gauging interest in upgrading to a more powerful server. The goal is to include additional Shiny apps and dashboards on the Shiny server, but this can be challenging due to constraints on global package loading. There may be a need to implement technical standards for Shiny apps and interactive tools that will be housed on the DFO server.

Discussion Summary

The following captures comments, questions and discussion points posed during the hands-on training and lunch-and-learn sessions above. Comments are not necessarily indicative of consensus or suggestions made by the workshop as a whole.

- Dashboards are an engaging and transparent way to both explore data internally and present results externally.
- In the world of open data, these tools offer increased transparency to audiences while ensuring that data stewards maintain control over data quality and interpretations.
- Science staff see a need for top-down guidance from CSAS, and infrastructure from IMTS and ODIS, but a one-size-fits-all approach will not work.
- Forcing everyone to switch to a new or standardized format is unadvisable, but some groups are keen to take advantage of these techniques and DFO should encourage this.
- The learning curve is relatively shallow for a simple dashboard, but as complexity builds, more expertise is needed. Familiarity with RMarkdown, Latex and/or HTML languages is beneficial in order to develop fully customizable applications and these require additional time to learn. Flexdashboard and Shiny users do not necessarily need to know Java and CSS languages (unless looks want to be customized), and they still need to know R and RMarkdown.
- Different packages suit different needs and have different syntaxes; flexdashboard is best for standalone products that do not require re-analysis, while Shiny is better if data require re-analysis based on user inputs within the tool.
- There may be computational limitations for large datasets (e.g. >10GB) or complex models.
- Potential for long-term gain in productivity/efficiency, with larger scale efforts at the beginning due to training needs. Experience at DFO in the Newfoundland and Labrador Region suggests that long-term rewards are worth it, however, incorporating these activities into work plans will need top-down support.

- The simplicity or complexity of a dashboard will depend upon the user building it. Depending on the complexity and goals, dashboards can take less than a day to create, or months. Regardless, updating the dashboard would take minutes given the benefits of reproducibility and reusability offered by well-written (organized and annotated) code. Following this workshop, within one afternoon, a dashboard was created using new skills acquired during the workshop to broadly disseminate workshop material.
- Building interactive tools with R allows version control using software such as Git.
- Considerations must be given to the Privacy Act when publishing data; when creating tools, all levels of filtering/sub-setting must be in line with data privacy constraints.
- Without a formal infrastructure/framework for development and publication of these interactive tools, it will be challenging to share code and be aware of what others have developed.

Discussion Summary about Moving Forward with the use of Interactive and Reproducible tools for Science advice

Reproducible documents are now developed to create and update CSAS publications. For instance, R packages have been developed in DFO Pacific region to generate an annual Research Document synopsis report showing all available fishery and biological data and basic model fits for 109 Pacific Groundfish species (Anderson et al. 2019). Participants described documents that could be standardized to report information efficiently to many stakeholders, and the potential to have interactive tools as supplementary material (for example, CSAS Science Updates). Some important considerations include: identifying the minimal baseline of information required for reproducible reports; how to standardize the manner in which information is processed, presented, and distributed through Open Data; what solutions (e.g., code) are available to implement this in a transparent and efficient manner; what standardization (e.g., data labels) could/should be achieved; and how reaching consensus based on the various approaches available and implemented can be achieved. This discussion highlighted the importance of developing “evergreen” documents where only specific sections of information are updated on an annual basis, and other ones remain static (e.g., description of the stock). There is a need to define methods that allow the communication of critical information that is specific to, and shared across, research areas (e.g., themes or stocks).

TESA is working on these approaches by discussing how to develop stock summaries. The International Council for the Exploration of the Sea (ICES) is also developing reports that extend beyond static reports (e.g., pdf documents), to provide executive summaries coming from each assessment. In these types of reports,

stakeholders can look more deeply at key sections and aspects they are particularly interested in. Dashboards were highlighted as complimentary approaches to increase efficiency. Some dashboards products could be developed for internal use and some can be developed as communication tools for the public. This is because different audiences would require different levels of interactivity and information to avoid miscommunication on key ideas. DFO has a series of annual reports in addition to stock assessment outputs that are starting to look at this type of reproducibility in reporting. These reports may include information from the Atlantic Zone Monitoring Program (AZMP), Cetacean Research Unit, the remote sensing group, MPA monitoring programs, cumulative effects research, State of the Ocean Reporting, and ecosystem indicators.

Developing complete and standardized reports could reduce the amount of work required subsequently to communicate outcomes, particularly if the reports are annual products. For example, the Cetacean Research Unit described how they are working towards standardizing approaches to improve efficiencies in their work. For acoustic sampling related research, interactive tools could support their work to document where sampling and/or acoustic recording has occurred and how the program changes year-to-year.

Data managers highlighted that data discovery is a fundamental step to improve efficiency across the Science sector, and that there are many tools beyond those available in R that are beginning to be implemented by the Maritimes and Gulf Regions for these purposes.

Challenges were raised on the differences in the approaches that staff implement in their everyday work. The challenges will remain on how to guarantee independence of the research units to best achieve their individual goals, while also supporting and encouraging the adoption and use of these new tools.

There are two main communication objectives: 1) communicating information for review by scientists, managers, and stakeholders to support departmental decision-making processes; and 2) communicating information to the general public. The material created for each objective requires consideration on the choice of language and level of detail; challenges include maintaining the quality and nuances of complex information while communicating in a summarized format.

Programming, interactive tools, and reproducible reports can be accomplished using programming languages other than R. Decisions on what language(s) to use and how to combine the benefits of various languages may present a challenge as ideas progress and more tools become available. Identifying specific goals for the development of interactive tools would be the first step to avoid duplication of efforts. Code review will soon become a vital component of the peer-review process. Just as we need to peer-

review our manuscripts, our code should be reviewed as well. This is not yet done widely outside software development circles, but it is good practice that will lead to fewer errors/bugs, security issues, and overall represents a learning opportunity for both the code author and reviewer. Ensuring we are using quality code for public facing and decision-making relevant tools are particularly critical, particularly in the context of open science.

Visualization of uncertainty was a specific topic that came up as part of this discussion as it is considered an important component of providing science advice. Models are predictions and improving the manner in which we communicate uncertainty will be an important component in the development and use of these tools.

This discussion ended with a very clear message: interactive tools are a choice. These tools have the potential to be used for a variety of needs, including the presentation of stock assessments. The use of traditional software like Microsoft Word, Excel, and Powerpoint remain valid, and interactive tools can help extend these approaches.

Day 2 – Session 4: BIO Seminar "Interactive Tools for Science Advice", November 6 2019

by Paul Regular

Please use the following citation for this section: Regular et al. Submitted.

This seminar was open to all staff at BIO with and without experience working in R programming. In the spirit of making material available to the entire science community, this seminar was recorded and made available in the workshop dashboard.

Abstract

Scientists across many fields are faced with the challenge of synthesizing and communicating information from large and complex data sets. The field of stock assessment is no exception, as the volume and variety of the data has grown alongside the computational methods used to integrate them. While this growth in data and model complexity has improved many stock assessments, the process of communicating key results to colleagues and stakeholders in a meaningful way has become more daunting and generally has not evolved at the same pace. The traditional approach of presenting information across a series of static slides often fails to convey the richness of information available and, as such, important patterns, assumptions, and details are easily overlooked. Here we contend that this problem can be mediated through the effective use of new open source tools for building interactive visualizations. These tools allow a broader audience to conduct detailed explorations of the results, leading to a deeper and collective understanding of both the data and models used to inform stock assessments. As a consequence, the peer review process is more open and accessible.

Learning Products: Workshop Dashboard

By Paul Regular and Catalina Gomez

The Interactive Tools Workshop for Science Advice provided basic training to develop R dashboards. With a shallow learning curve, staff in the DFO Maritimes Region started developing dashboards for their own work requirements. As a proof of concept, we developed an interactive tool for Science Advice dashboard as supplementary material for these proceedings and as a way to inspire other colleagues to use these tools to interact with their data and analysis, to create interactive supplementary materials for meetings, papers, reports or posters, and to generally improve the way we communicate our science. The complete workshop dashboard can be assessed using the following steps:

Instructions for non-R users

- Download the zip file from GitHub: https://github.com/AtlanticR/bioRworkshops/blob/master/16_ToolsScienceAdvice/ToolsScienceAdvice.7z
- Extract the html and save it in your machine (do not open),
- Open the html file with Google Chrome.

Instructions for R users

Clone the full series of workshops via RStudio:

- Open RStudio
- File > New Project > Version Control
- Select Git
- Clone Git Repository
- Repository URL: https://github.com/AtlanticR/bioRworkshops.git
- Project directory name: bioRworkshops

The dashboard is in the folder labeled: ToolsScienceAdvice. You can view the dashboard by opening the file ToolsScienceAdvice.html in Google Chrome. You can re-create the dashboard in RStudio by opening ToolsScienceAdvice.Rmd and clicking “Knit”.

III: INTERACTIVE TOOLS FOR SCIENCE ADVICE DASHBOARD: LUNCH-AND-LEARN SESSION

By Paul Regular, Peter Kraska, and Catalina Gomez, December 6, 2019 at BIO

The Learning and Development series strives to provide accessibility of all material generated from R workshops with the goal of supporting our vision of open, reproducible, and collaborative science. This third series was hosted as part of the BIO R lunch series and was open to everyone in DFO Science Maritimes Region interested in R (WebEx capabilities were available; Table 1). During this session, Paul Regular provided a short presentation showcasing dashboards created in the Newfoundland and Labrador Region, similar to the examples delivered at BIO's special seminar (part of Workshop Series Component 2; Table 1). This presentation was followed by a description of the Interactive Tools for Science Advice dashboard created as a compliment to this proceedings (see Workshop Series Component 2; Table 1). The presentation included:

- A description of the general layout of the dashboard, and all the material available for anyone interested in learning more about these tools.
- A description of the R code used to develop the dashboard and the examples using data from DFO's Ecosystem Research Vessel Survey.

Presenters highlighted the simplicity in the code to animate and link plots and tables across different tabs in this html. Peter Kraska presented on the infrastructure that may be required to host these types of interactive tools at DFO. The majority of staff that attended this series were not participants in the Interactive Tools Workshop for Science Advice (Workshop Component 2; Table 1). Many expressed interest in learning more about these types of tools and approaches.

SUMMARY

This workshop series offered scientists the opportunity to come together, learn, and exchange information in a collaborative setting related to the use of interactive tools for science advice. Within DFO, these tools may facilitate data exploration, quality control and sharing between groups and individuals. They may improve the communication of science advice to both internal decision-makers and external stakeholders by opening up scientific analyses and making the science advice process more transparent and engaging. Developing reproducible tools using version control can maintain institutional knowledge, by retaining as much past work as possible as people retire or move to other jobs. Workshop participants not only learned how to use these tools, they also participated in discussions on operationalizing these tools within the CSAS framework and the potential challenges to advancing these approaches. This initiative facilitated relationship building amongst divisions within the Maritimes Region Science Branch, and facilitated other invaluable network building and coding support opportunities that

collectively build on the active and collaborative R community within the Maritimes Region.

Many DFO Science staff are interested in developing interactive tools using the packages explored during this workshop as they offer R users full control over the final product. DFO Science staff can use their subject-matter expertise to develop highly-customized tools to communicate their science advice more effectively. However, the flexibility afforded by these packages poses a challenge for the development of DFO Information Technology (IT) infrastructure to support the publication and archiving of these products. Formal guidance may also be required to ensure that interactive tools are recognized as a valuable addition to the science advice process so that staff can receive the necessary support to advance these approaches for their research. IT-supported implementation of interactive tools may also create opportunities to automate processes, which could create new efficiencies in science programs.

Workshop evaluations completed by participants were positive. Participants noted the value in these tools and found the workshop interesting and applicable. Many enjoyed the opportunity to engage with staff from different divisions while learning and during discussions. They reported that the learning experience was of high quality and there was interest in future workshops on similar topics, such as cloud computing, spatial modelling, R coding, and Shiny.

ACKNOWLEDGMENTS

Special thanks to Tana Worcester for encouraging the principles of open science, collaboration and transparency that have inspired the R Learning and Development initiative. Many thanks to Rémi Daigle and Jeff Jackson for reviewing and providing feedback on this manuscript. This workshop series would not have been possible without the interest and participation of staff in the Maritimes Region that provided ideas and support to prepare, deliver, and implement these workshops. This workshop was possible with the additional support of Darlene Smith, Javier Murillo, Brad Hubley, Tammy Blair, Trish Hopkins, Natasha Power, and Adam Brisson. Funding for the Interactive Tools for Science Advice Workshop Series was provided by the Maritimes Regions DFO Science Branch Management Committee (BMC). The Maritimes Region Science Sector includes Learning and Development as part of its action plan to address the results of the 2018 Public Service Employee Survey results. This workshop was funded as a Learning and Development opportunity for technical training. The workshop's organizing committee was composed of the following DFO Science staff: Catalina Gomez (CESD), Jessica Sameoto (PED), Freya Keyser (PED), Lindsay Beazley (OESD), Javier Murillo-Perez (OESD), Kiyomi Ferguson (OESD) and Brad Hubley (PED).

REFERENCES

Allaire, J. 2017. Flexdashboard: R markdown format for flexible dashboards. Available from https://CRAN.R-project.org/package=flexdashboard

Anderson, S.C., Keppel, E.A., Edwards, A.M. 2019. A reproducible data synopsis for over 100 species of British Columbia groundfish. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/041. vii + 321 p

Bossdorf, O., Parepa, M., and Fischer, M. 2009. Climate-neutral ecology conferences: just do it! (October): 10223. doi:10.1016/j.tree.2009.09.006.

Chang, W., and Borges Ribeiro, B. 2018. Shinydashboard: Create dashboards with 'shiny'. Available from https://CRAN.R-project.org/package=shinydashboard

Cheng, J., Karambelkar, B., and Xie, Y. 2018. Leaflet: Create interactive web maps with the javascript 'leaflet' library. Available from https://CRAN.R-project.org/package=leaflet

Cheng, J. 2016. Crosstalk: Inter-widget interactivity for html widgets. Available from https://CRAN.R-project.org/package=crosstalk

Chang, W., Cheng, J., Allaire, J. J., Xie, Y., and McPherson, J. 2019. shiny: Web Application Framework for R. R package version 1.3.2. Available from https://CRAN.R-project.org/package=shiny

Edwards, A.M., Duplisea, D.E., Grinnell, M.H., Anderson, S.C., Grandin, C.J., Ricard, D., Keppel, E.A., Anderson, E.D., Baker, K.D., Benoît, H.P., Cleary, J.S., Connors, B.M., Desgagnés, M., English, P.A., Fishman, D.J., Freshwater, C., Hedges, K.J., Holt, C.A., Holt, K.R., Kronlund, A.R., Mariscak, A., Obradovich, S.G., Patten, B.A., Rogers, B., Rooper, C.N., Simpson, M.R., Surette, T.J., Tallman, R.F., Wheeland, L.J., Wor, C., and Zhu, X. 2018. Proceedings of the Technical Expertise in Stock Assessment (TESA) national workshop on 'Tools for transparent, traceable, and transferable assessments,' 27–30 November 2018 in Nanaimo, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 3290: v + 10 p

Gomez, C., Lawson, J. W., Wright, A. J., Buren, A. D., Tollit, D., & Lesage, V. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. Canadian Journal of Zoology, 94, 801–819. Available from https://doi.org/10.1139/cjz-2016-0098

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from https://www.R-project.org/

Regular P, Robertson G. Rogers R., Lewis K. Improving the communication and accessibility of stock assessment using interactive visualization tools. Submitted. CJFAS.

Sievert, C. 2018. plotly for R. Available from https://plotly-book.cpsievert.me

Fox, H.E., Kareiva, P., Silliman, B.R., Hitt, J., Lytle, D.A., Halpern, S., Hawkes, C. V, Lawler, J., Neel, M., Olden, J.D., Martin, A., Smith, K., and Tallis, H. 2009. Why do we fly? Ecologists' sins of emission. Front. Ecol. 7(6): 294–296.

Matheus R, Janssen M and Maheshwari D. 2018. Government Information Quarterly. Available from https://doi.org/10.1016/j.giq.2018.01.006

McHenry, J., Welch, H., Lester, S. E., and Saba, V. 2019. Projecting marine species range shifts from only temperature can mask climate vulnerability. Global Change Biology 25 (12): 4208-4221.

Wickham. 2016. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Appendix 1. Workshop Agenda

Agenda of the Interactive Tools for Science Advice Workshop. November 5-6, 2019.

November 5, 2019, NAFO Secretariat boardroom		
Time	**Item**	
08:45 - 9:00 am	Opening remarks by the Habitat Science WG executive committee, introduction of workshop participants	Lindsay Beazley
09:00 - 10:00 am	Interactive Tools for Science Advice: workshop introduction	Paul Regular
10:00 - 10:15 am	Break / code trouble shooting - download R packages if required	
10:15 - 12:00 m	Hands-on workshop (Part 1): Stock assessment output dashboard in R	Paul Regular
12:00 - 12:45 pm	Lunch break (Lunch not provided)	
12:45 - 2:45 pm	Hands-on workshop (Part 2): Stock assessment output dashboard in R	Paul Regular
2:45 - 3:00 pm	Break / welcome invited guests from BIO to discuss workshop goals and path forward to apply training to Science needs	
3:00 - 3:05 pm	Welcome of new participants to post-coding discussion and round table	
3:05 - 3:10 pm	Collaboration & Science Advice	Opening remarks by Tana Worcester
3:10 - 3:25 pm	Extensions of interactive tools for oceanographic data: is it possible?	Presentation by Chantelle Layton
3:25 - 3:35 pm	Extensions of interactive tools for spatial data: exploring dreams and possibilities	Presentation by Freya Keyser
3:35 - 3:45 pm	R Server	Brief presentation by Peter Kraska
3:45 - 4:30pm	Discussion of ideas and final remarks	Jessica Sameoto and all
6:15 PM	Nerd nite Halifax	Andrew Wright
November 6, 2019, Hayes boardroom		
Time	**Item**	**Description**
10:00 - 11:00 am	Interactive Tools for Science Advice: BIO Special Seminar by Paul Regular	Paul Regular
1:00 - 4:00 pm	Development of R flexdashboard for the workshop series	Paul Regular and Catalina Gomez

Appendix 2. Attendee List

List of participants from the Interactive Tools for Science Advice Workshop, November 5, 2019. Participants denoted with a * were only available for the final discussion session.

Participant	Sector	Science Division	Theme
Catalina Gomez	Science	CESD	Marine Spatial Planning
Jessica Sameoto	Science	PED	Scallop and Benthic Habitat Unit
Kiyomi Ferguson	Science	OESD	Climate Change
Lindsay Beazley	Science	OESD	Coral & Sponges
Javier Murillo	Science	OESD	Coral & Sponges
Brad Hubley	Science	PED	Halibut Unit
Andrea Hilborn	Science	OESD	Remote-sensing Unit
Dave Keith	Science	PED	Scallop and Benthic Habitat Unit
Ryan Stanley	Science	CESD	Marine Protected Areas
Brendan Wringe	Science	PED	Salmon Unit
Noreen Kelly	Science	CESD	Cumulative Effects
Susan Heaslip	Science	CESD	Marine Protected Areas
Anna Serdynska	Oceans Management		Marine Spatial Planning
Angelia Vanderlaan	Science	OESD	Cetacean Research Unit
Phil Greyson	Science	CESD	Marine Spatial Planning
Mike McMahon	Science	PED	Data Manager
Javier Guijarro Sabaniel	Science	CESD	Cumulative Effects
Chantelle Layton	Science	OESD	Oceanography
Andrew Wright	Science	OESD	Cetacean Research Unit
Jamie Tam	Science	OESD	Ecosystem Approaches
Danielle Dempsey	Science	PED	Ecosystem Approaches
Gordana Lazin	Science	SPAD	Marine Spatial Planning
Freya Keyser	Science	PED	Scallop and Benthic Habitat Unit
Peter Kraska	Science	CESD	Data Manager
Clark Richards	Science	OESD	Oceanography
Pam Emery	Science	OESD	Cetacean Research Unit
Hilary Moors-Murphy*	Science	OESD	Cetacean Research Unit
Diana Cardoso*	Science	OESD	Data Manager
Tana Worcester*	Science	SPAD	Marine Spatial Planning