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Tethys and Annex IV Annual Report for FY 2016

September 2016

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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Seattle, Washington 98109

Summary

The purpose of this report is to provide an overview of the Annex IV activities carried out during FY16 and to summarize the overall usage and enhancements made to *Tethys* during FY16. The first section of this report highlights Annex IV progress and describes the record of events organized and supported by Annex IV, and how these accomplishments are facilitating the advancement of this project and creating a commons around Annex IV and *Tethys*. The second section of this report summarizes the analytical data for *Tethys* over FY16 with respect to metrics and goals, and the various enhancements developed throughout the year.

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1.0 Introduction

To help organize and disseminate information and data to the marine energy community, the U.S. Department of Energy's (DOE) Wind and Water Power Technologies Office (WWPTO) has directed the Pacific Northwest National Laboratory (PNNL) to create *Tethys*. *Tethys* is a publicly accessible, online knowledge management system that gathers, organizes, curates, and provides access to information on the environmental effects of marine energy and wind development. *Tethys* also facilitates connectivity and collaboration among the marine renewable energy community by providing a means for communicating and disseminating important information and data on stressor/receptor interactions between devices and the marine environment.

Annex IV, led by the US with the DOE WWPTO acting as the Operating Agent, is an international collaborative project among member nations of the Ocean Energy Systems (OES). The Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) are also partners in Annex IV. Information collected through Annex IV is housed within *Tethys*, primarily consisting of metadata from a wide range of international ocean energy developments and research projects focused on the environmental effects of marine renewable energy. The third phase of Annex IV was recently approved by OES to extend the annex for an additional four years (May 2016 - May 2020).

The purpose of this report is to address year end SMART milestones for the *Tethys* and Annex IV projects under DOE's WWPTO Annual Operating Plan (AOP). The milestones are as follows:

Annex IV:

All FY16 activities will be completed, as described in the requirements of the Annex IV continuation proposal for Phase 2, as well as pertinent activities under the Phase 3 proposal. A report on progress will be delivered to DOE. By completing these requirements, *Tethys* and Annex IV will increasingly be an asset to the MHK research, industry, and regulatory communities to reduce duplication of research effort, highlight areas where environmental questions are being resolved, and connect users to each other through both IT infrastructure (*Tethys*), as well as direct researcher to researcher interactions.

Tethys:

Progress will be measured by the ability of *Tethys* to meet or surpass the following qualitative and quantitative performance metrics: 1) Total visits in FY16 up 10% from FY15; 2) 90% of links in *Tethys* will be active; 2) a minimum of 50 new documents on MHK research and monitoring will have been added to *Tethys*; 3) four webinars, two expert forums, and 20 *Tethys* Blasts, will have been completed; and 4) FY16 peer review will reflect the satisfaction of *Tethys* peer reviewers with site usability, functionality, and content.

2.0 Annex IV

2.1 Metadata Collection

As part of the Annex IV effort, PNNL seeks information on environmental data collection for wave and tidal projects and research studies, in the form of new metadata forms, on an ongoing basis. Updates to existing metadata forms are solicited every 12-18 months as outlined in the *Tethys* Management Plan. These metadata are collected through direct communication with Annex IV country analysts, international wave and tidal project developers, and the marine energy research community, with assistance from Aquatera Limited. A summary of the Annex IV metadata collection status and efforts in FY16, are shown in Table 1.

Table 1. Collection status of Annex IV metadata forms, as of September 20th 2016.

Statistic	Project Sites	Research Studies
Total metadata forms housed in <i>Tethys</i> .	84 forms	58 forms
New metadata forms added in FY16.	4 forms	2 forms
Number of metadata forms removed in FY16. (i.e. canceled projects with no environmental data)	0 forms	7 forms
Total metadata forms updated within the last 18 months.	11 forms	6 forms
Total metadata forms marked as complete and no longer require updates.	33 forms	38 forms

Requests for updates were sent out for all 142 metadata forms, but responses were limited (Figure 1). Many of the forms with pending updates were received during the initial metadata collection in 2012, and did not establish a primary point of contact. Due to the lack of response regarding request for updates of metadata forms, we intend to initiate a new approach during FY17. Attempts will be made to complete these forms using existing publications. If publications are not readily available outdated metadata forms will be removed from *Tethys*.

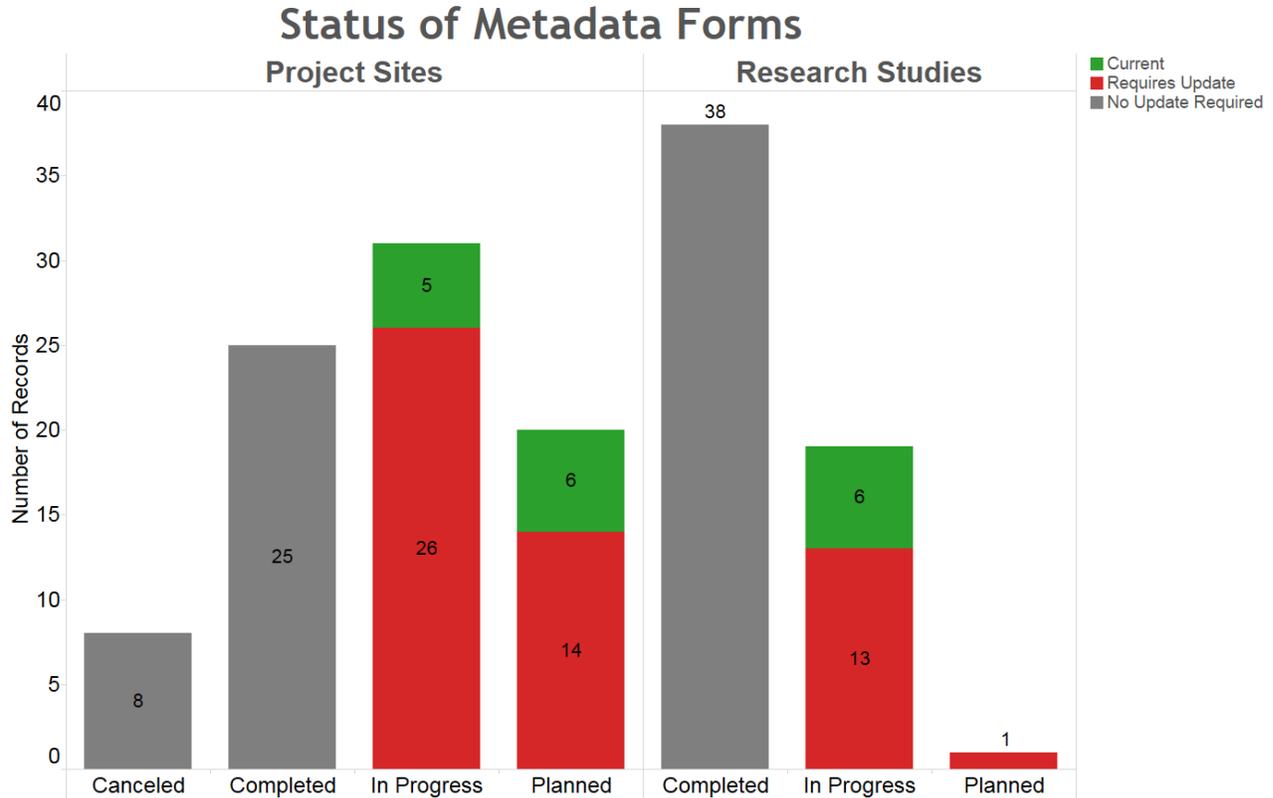


Figure 1. Status of Metadata forms: gray no longer require updates because they are complete, green have been updated within the last 18 months, and red need updating.

Recognizing that the manual, systematic outreach for obtaining updates to metadata forms had become inefficient, a new metadata management system was created during FY16. The new system improves on the previous by adding features and automated processes which will expedite the management of existing forms. Filtering improvements to tabulated summaries of the metadata information now facilitates expedited viewing and management of the forms and their status. Additionally, the system is now capable of generating email templates aimed at updating existing information and creating new metadata forms. Automated features will send emails to metadata points of contact to request updates every 12 to 18 months. The benefits of this system will be seen in upcoming years as clear points of contact are established with all new forms.

The focus for metadata forms in FY17 will be to update or delete all forms from 2012 (represented as red bars in Figure 1), and to focus on the collection of new metadata forms.

2.2 FY16 Activities

The last year has seen the conclusion of Phase 2 and the inception of Phase 3 of Annex IV. Annex IV activities were all aimed at and designed to encourage international collaboration and exchange of information on the most pressing potential environmental impacts of marine renewable energy, including:

- **Annex IV Environmental Webinars**

Webinars continued during the second and third phases of Annex IV, to disseminate new research and associated information to an international audience of stakeholders. These webinars focus largely on key environmental concerns that burden siting and permitting of wave and tidal projects worldwide, but also include regional topics. Four webinars were held during FY16, in addition to one webinar held about the Large Scale Interactive Coupled Modelling of Environmental Impacts of Marine Renewable Energy Farms (LINC) project. The webinars were hosted by PNNL, and are archived on *Tethys*:

- **Adaptive management in the Marine Renewable Energy Industry**, 27 January 2016

This webinar focused on adaptive management, and how it can be used as an effective decision making process in the face of uncertainty for the MRE industry. Speakers for this webinar included: Kim Hatfield, NOAA; Nate Johnson, ORPC; and Finlay Bennet, Marine Science Scotland. The live international audience for this webinar consisted of 85 connections. Subsequent downloads of the webinars added 1,126 views¹. A recording of this webinar, is available on *Tethys* at: <http://tethys.pnnl.gov/events/adaptive-management-marine-renewable-energy-industry-webinar>.

- **Collision Risk - Understanding and Resolving the Problem in Scotland**, 15 March 2016

Following the International Conference on Ocean Energy (ICOE 2016) at Edinburgh, Scotland, this webinar focused on the key challenges within the permitting/consenting processes related to collision risk. Speakers for this webinar included: Dr. Ian Davies, Marine Science Scotland; George Lees, Scottish Natural Heritage; Dr. Ben Wilson, Scottish Association of Marine Science; and Dr. Carol Sparling, Sea Mammal Research Unit. The live international audience for this webinar consisted of 75 connections. Subsequent downloads of the webinars added 760 views¹. A recording of this webinar, is available on *Tethys* at: <http://tethys.pnnl.gov/events/collision-risk-webinar-understanding-and-resolving-problem-scotland>.

- **State of the Science Report**, 10 May 2016

After the release of the State of the Science report, this webinar was held to provide an overview of the report and serve as outreach. The speaker for this webinar was Dr. Andrea Copping, PNNL. The live international audience for this webinar consisted of 53 connections. Subsequent downloads of the webinars added 614 views¹. A recording of this webinar, is available on *Tethys* at: <http://tethys.pnnl.gov/events/2016-annex-iv-state-science-webinar>.

- **Role of Biofouling in Marine Renewable Energy Development**, 12 July 2016

This webinar focused on the role of marine growth in efficiency, maintenance, and structural integrity of marine renewable energy devices. Speakers for this webinar included: Dr. Raeanne Miller, Scottish Association for Marine Science;

¹ Through September 20th 2016

and Dr. Jennifer Loxton, University of Highlands and Islands. The live international audience for this webinar consisted of 53 connections. Subsequent downloads of the webinars added 452 views¹. A recording of this webinar, is available on *Tethys* at:

<http://tethys.pnnl.gov/events/role-biofouling-marine-renewable-energy-development-webinar>.

- **Large Scale Interactive Coupled Modelling of Environmental Impacts of Marine Renewable Energy Farms (LINC), 28 April 2016**

This webinar was held in partnership with the LINC project, showcasing the results of an Engineering and Physical Sciences Research Council (EPSRC) grant on modeling the effects of large arrays on the environment. Speakers for this webinar included: David Culley, Imperial College London; Dr. Louise Kregting; Pia Schuchert; Dr. Pal Schmitt, Queens University Belfast; Dr. Johan Van der Molen; and Dr. Julian Metcalf, CEFAS. The live international audience for this webinar consisted of 62 connections. Subsequent downloads of the webinars added 564 views¹. A recording of this webinar, is available on *Tethys* at:

<http://tethys.pnnl.gov/events/linc-webinar>.

- **Annex IV Expert Forums**

In addition to environmental webinars, Annex IV holds online expert forums through *Tethys*. These forums are intended to target specific issues and interactions with high levels of uncertainty that continue to hinder the advancement of research efforts and the industry as a whole, and that are being addressed by multiple research groups worldwide. Two expert forums were held during FY16:

- **Potential Risks to Larvae and Plankton from Tidal Turbines, 11 August 2016**

This expert forum discussed risk to plankton, lobster and fish larvae from tidal turbines, a concern that was raised specifically in the Bay of Fundy. Dr. Anna Redden from Acadia University organized this meeting, while Dr. Andrea Copping from PNNL led the discussion, with participation from 17 other researchers and scientists. The recording has been viewed 47 times¹. A recording of this expert forum is available on *Tethys* at:

<http://tethys.pnnl.gov/events/expert-forum-potential-risks-larvae-and-plankton-tidal-turbines>.

- **Risk of Collision Between Marine Mammals and Tidal Turbines - Assessing that the Population Level, 16 August 2016**

This expert forum focused on the population level assessment of collision risk of animals with tidal turbines, assessing consequences, setting thresholds, modeling population impacts, and examining regulations. Dr. Carol Sparling from SMRU Consulting led this discussion, with participation from 17 other researchers and scientists. The recording has been viewed 62 times¹. A recording of this expert forum is available on *Tethys* at: <http://tethys.pnnl.gov/events/expert-forum-risk-collision-between-marine-mammals-and-tidal-turbines-assessing-population>.

- **Annual Peer Review (Targeted)**
During Q3 of FY16 requests to provide a peer review of *Tethys* were sent to all Annex IV country analysts, as well as to a group of 41 other MRE experts. A total of 14 MRE reviews were received from 10 countries (Canada, Ireland, Japan, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom, and United States). A total of 98 comments were submitted from the reviewers. Additional details of the comments and PNNL responses are provided in Section 2.5.
- **Annual Peer Review (Survey Monkey)**
In Q3 of FY16, a short 5-question survey was created with Survey Monkey and distributed to a broad audience via *Tethys* Blasts, the *Tethys* Crawler, and social media. A total of 72 responses gave insight into usage, effectiveness of features, and feedback from users. Additional details of the Survey Monkey are provided in Section 2.5.
- **Annex IV Country Analyst Meetings**
The primary focus of work with the Annex IV country analysts during FY16 was to plan for, review, and develop outreach efforts for, the State of the Science report. A group of analysts met with PNNL and DOE staff in person in conjunction with the ICOE conference in Edinburgh in February 2016 to discuss progress in the Annex IV, the roll out of the State of the Science report, and to plan for the third phase of Annex IV. Three country analysts (Anne Marie O’Hagan of Ireland, Teresa Simas of Portugal, and Juan Bald of Spain) were authors on the State of the Science report, while most other analysts provided input and review of the report and associated products.

2.3 Annex IV State of the Science Report

The major effort for Annex IV during FY16 was writing, producing, reviewing, and publishing the State of the Science (SoS) report (Table 2). The initial draft of SoS was completed in FY15, with review processes starting in late FY15, including a workshop held in conjunction with the EWTEC conference in France in September 2015. During FY16, review comments from Annex IV members were incorporated as well as input received during the EWTEC workshop. From the Annex IV and EWTEC comments, a new draft was prepared and sent out for peer review to carefully selected reviewers; the report draft was also sent to OES members at the same time. Comments from the peer and OES reviewers were incorporated and the draft for public review was released at the time of the ICOE conference in Edinburgh in February 2016. Input received on this release was incorporated and the final SoS released by WWPTO at the National Hydropower Association conference in Washington DC in April 2016. A workshop on the report was held in conjunction with the Marine Energy Technology Symposium (METS), co-located with the NHA conference. At that time, SoS was mounted on *Tethys* and an active outreach effort begun.

Table 2. Chapter titles and authors for the State of the Science Report.

Chapter Title	Author
Introduction	A. Copping
Potential Environmental Interactions Associated with the Deployment of Marine Renewable Energy Devices	L. Hanna, A. Copping

Collision Risk for Animals Around Tidal Turbines	G. Zydlewski, G. Staines, C. Sparling, E. Masden, J. Wood
Risk to Marine Animals from Underwater Sound from Marine Renewable Energy Devices	N. Sather, A. Copping
Changes to Physical Systems: Energy Removal and Changes in Flow	J. Whiting, A. Copping
Effects of EMF on Marine Animals from Electrical Cables and Marine Renewable Energy Devices	A. Gill
Changes in Habitats Caused by Marine Renewable Energy Devices: Benthic Habitats and Reefing Patterns	N. Sather, A. Copping, G. Zydlewski, G. Staines
Marine Spatial Planning and Marine Renewable Energy	AM. O'Hagan
Case studies that Examine Siting and Permitting/Consenting of Marine Renewable Energy Devices	T. Simas, J. Bald
Summary and Path Forward for Marine Energy Monitoring and Research	A. Copping, I. Hutchison

In addition to the report itself, the executive summary of SoS was prepared as a standalone document and released as a public draft in February 2016 and a final in April 2016. The executive summary was translated by the appropriate Annex IV members into six languages besides English, and mounted on *Tethys*. Eight one-page summaries (since dubbed “short science summaries”) were prepared and circulated that address key interactions of MRE and the marine environment. These summaries have been widely distributed on paper and electronically via *Tethys*.

SoS outreach included a variety of online and in person presentations, an Annex IV webinar on the report, targeted online meetings with agency staff, a teleconference presentation at the AWATEA (New Zealand wave and tidal conference), a workshop at OWET (Oregon Wave Energy Trust) conference, and numerous less formal presentations and discussions.

2.4 Creating a Commons

A key component of the second phase of Annex IV was to ensure that PNNL, with support from DOE, facilitated the creation of a commons around the Annex IV project and *Tethys*. The purpose of this effort was to attract a larger and more diverse set of users and participants to use *Tethys* and Annex IV as tools to access and share information, and to facilitate communication and collaboration among the international marine renewable energy community.

All environmental webinars and expert forums have been recorded and posted on *Tethys*, driving more visitors to the website in an attempt to reach a broader audience and generate comment threads on current issues and concerns related to the potential environmental effects of marine renewable energy. As each event is planned, notice is provided to prospective participants through *Tethys* Blasts, the *Tethys* crawl, *Tethys* Events Calendar, and direct email notice to the 1000+ email list. Google Analytics tracks the number of views on each page since their original posting (counts taken on September 20th, 2016), shown in Table 3.

Table 3. Viewership summary for Annex IV webinars and expert forums: FY14 – FY16.

Year	Title	Views*	Live Attendees
Webinars			
FY14 Webinars 1-2	Instrumentation Workshop	364	133
	Interactions of Marine Mammals and Birds around Marine Energy Devices	408	134
FY15 Webinars 3-6	Tidal Energy Research in the Bay of Fundy	961	60
	Effect of Energy Removal on Physical Systems	344	55
	Effects of Electromagnetic Fields on Marine Animals	1,367	100
	Marine Renewable Energy Test Centers and Environmental Effects Research	850	66
FY16 Webinars 7-10	Adaptive Management in the Marine Renewable Energy Industry	1,126	85
	Collision Risk - Understanding the Problem in Scotland	760	75
	State of the Science Report	614	53
	Role of Biofouling in Marine Renewable Energy Development	452	53
Expert Forums			
FY14 Expert Forum 1	Analyzing Acoustic Data around Marine Energy Devices	159	21
FY15 Expert Forum 2	Risk of Collision between Marine Animals and Tidal Turbines	294	21
FY16 Expert Forums 3-4	Potential Risks to Larvae and Plankton from Tidal Turbines	47	17
	Risk of Collision between Marine Mammals and Tidal Turbines - Assessing at the Population Level	62	17

*Views are tracked as pageviews within *Tethys*.

A total of 27 bi-weekly *Tethys* Blasts were distributed during FY16 to a growing list of 1,016 subscribed users, highlighting new *Tethys* content and industry news. *Tethys* Blasts have also been used to highlight particular aspects of the program (e.g., to solicit input on the Annex IV State of the Science), to advertise calls for abstracts from related conferences, to advise users of events and conferences in the US and abroad and to highlight DOE activities such as funding opportunity announcements (FOAs).

A total of 8 new *Tethys* Stories were written by PNNL staff as well as members of the *Tethys* community to highlight events and other topics that were relevant to the marine renewable energy industry. Social media (i.e. Facebook, Twitter) was used to announce events and stories on *Tethys* and to reach a broad audience and drive traffic to *Tethys*. The Facebook page currently has 135 likes and the Twitter account has 215 followers. Additionally, *Tethys* has 478 registered users, who have taken steps to complete profiles and have their information available to the community at large.

2.5 *Tethys* Peer Review

There were 14 respondents to the detailed peer review that submitted a total 98 comments. All respondents have a background in MRE and familiarity with environmental issues that may affect permitting of these devices. The majority of MRE feedback generally targeted aspects of *Tethys* functionality and content. Comments focused on content preferences, improvements to search functions and speed, and functionality for the Map Viewer and Knowledge Base. The following list illustrates high-level comments:

- Add more socio-economic and legal research content;
- Use word associations to help users find related content;
- Need to increase speed on certain pages (Map Viewer, Knowledge Base);
- Improvements needed for Map Viewer (add country facet, improve clustering);
- Addition of check boxes (as well as facet boxes) could make searching more straightforward;
- Regulatory information should be updated and standardized;
- Search functionality improvements are needed; and
- Search capabilities on broadcast and connection pages could be improved.

The detailed peer review helps to understanding the perceptions of *Tethys* by users. Some detailed comments were noted but due to constraints of budget and focus, fall outside the scope of *Tethys*. Other comments proved very helpful and have led to implementation through further IT development or content management. In addition, some comments are not feasible with current technology, but the intent of the comment has led to further thinking about the problem and potential future solutions. Many of the issues raised by the FY16 peer reviewers, including improvements and new functionality for the Map Viewer, will be addressed in FY17 as solutions are identified.

To solicit additional reviews of *Tethys* from a broad audience, a request for reviews was distributed to the *Tethys* community via emails, *Tethys* Blasts, social media, and announcements on the home page, to be collected using Survey Monkey. A total of 72 responses were received. Many of the answers provided high-level suggestions for improvements. Two responses are detailed in Figure 2 and Figure 3.

How do you use Tethys? Please check all that apply.

Answered: 72 Skipped: 0

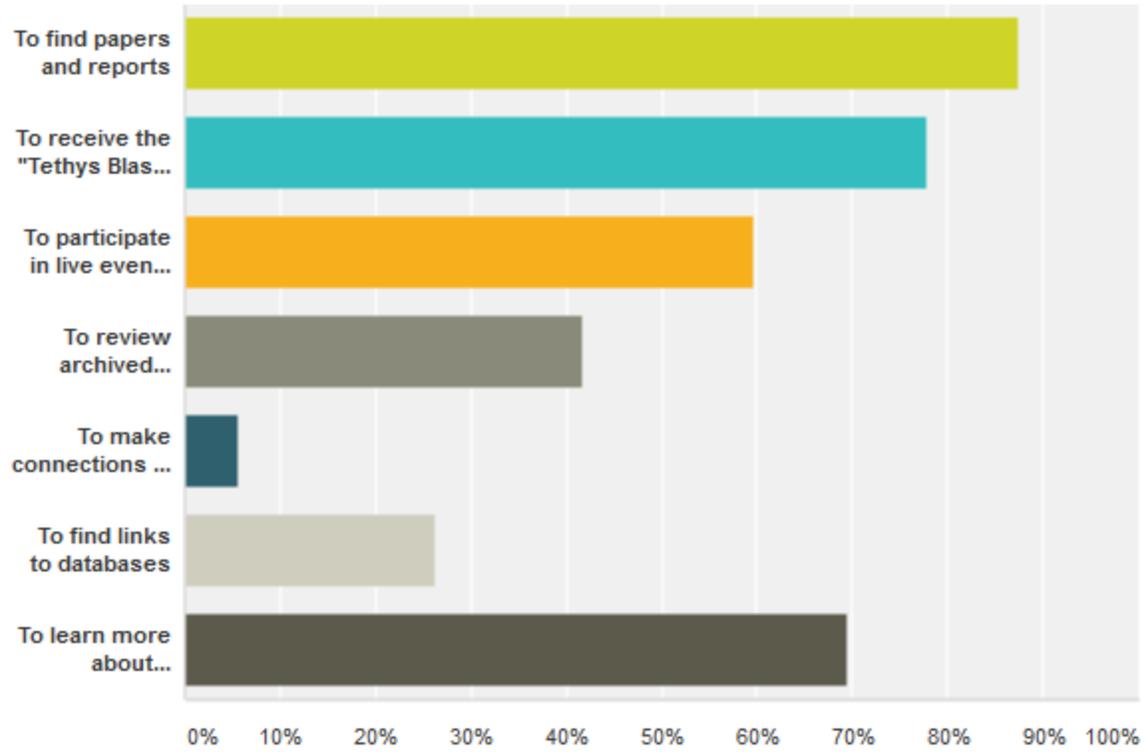


Figure 2. Details on how the *Tethys* community utilizes the website.

Please rate your experience on Tethys from 1 (not very helpful) to 5 (extremely helpful).

Answered: 72 Skipped: 0

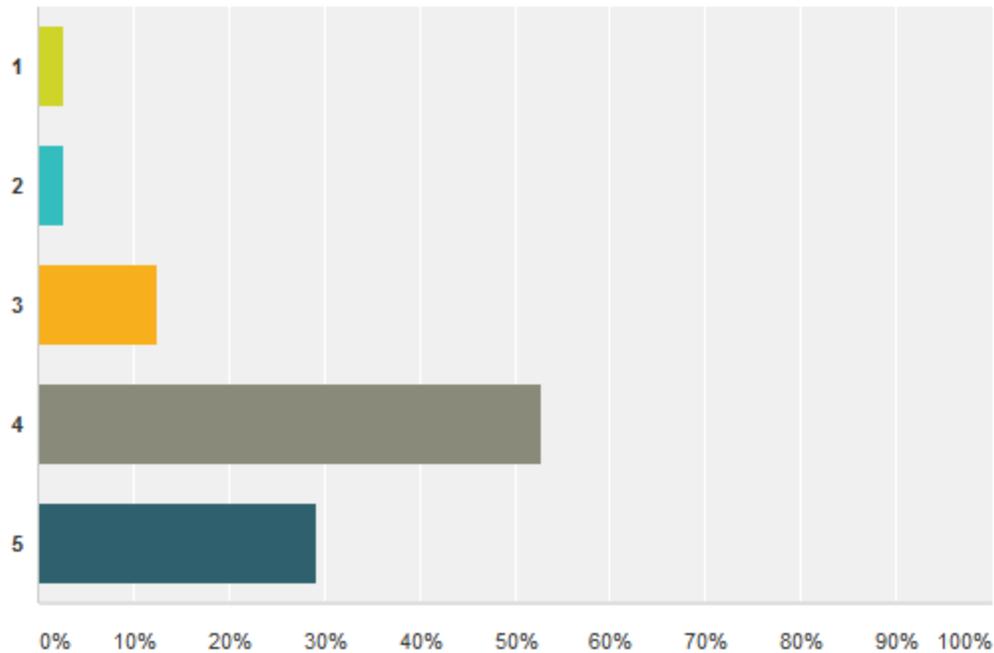


Figure 3. Indicator of value that people assign to *Tethys*.

A report of the FY16 peer review and past peer reviews are available on *Tethys*: <http://tethys.pnml.gov/deliverables>.

2.6 Overview of *Tethys* IT Development Activities

Tethys IT development tasks during FY16 focused on improving efficiency in many aspects of the site by reducing redundancies and automating tasks, as well as improvement made for adding content and improving the user experience. During FY16, major IT development tasks included overhaul to the management of Annex IV metadata forms and link checks; automated reminders and processes were established to streamline time consuming tasks like *Tethys* Blasts and *Tethys* Stories, which further ensured the consistency of processes that control *Tethys* content. Over 800 new documents were added to *Tethys* throughout the year, with source material collected from proactive searches of the scientific and industry literature, email alerts, recommendations from the MRE community, reviewing references from key reports and papers, and WILD imports (for land-based wind). To better accommodate wind energy in *Tethys*, 12 new tags were added, requiring the retagging of over 1,000 documents. The user experience is in the process of being improved by significantly increasing loading speeds on key pages that were far too slow for today's standards, in addition to fixing bugs and keeping the site operational (Appendix A).

During FY17, further speed increases will be implemented, the functionality of the Map Viewer will be examined, text search processes will be improved, and site security will be increased. Additionally, work completed by Matt Preisser, a DOE Science Undergraduate Laboratory Intern, will be incorporated into *Tethys*. In collaboration with Annex IV analyst Anna Redden, Matt catalogued data collected from the Bay of Fundy and designed a plan to incorporate the data into *Tethys*.

2.7 Future Activities

As Phase 3 of Annex IV calls for continuation of activities from Phase 2, as well as increased foci, the PNNL team will continue to strive to make *Tethys* and other activities more efficient, and to identify *Tethys* content or activities that can be reduced or discontinued based on high level of effort or low impact.

3.0 Tethys Performance Metrics

3.1 Annual Performance Metrics for FY16

Performance metrics are collected and analyzed quarterly, as well as annually, for *Tethys*. Metrics and goals were defined in the *Tethys* Management Plan, developed in FY14 and available on the Deliverables page. To minimize bias in the summarized metrics, all traffic from PNNL has been removed from these metrics. The metrics have been calculated from October 1st 2015 to September 20th 2016; the last 10 days of September have been estimated and the totals extrapolated to include a full year of data (Table 4). Unadjusted metrics, reports for previous quarters, webinar attendance, and a list of recently added documents are available on *Tethys* at: <http://tethys.pnnl.gov/deliverables>.

Table 4. Annual Performance Metrics for FY16.

Metric	Goal	FY16 Results	Compare to FY15 Data
Total Visits	10% increase on annual basis, to be tracked on revolving quarterly basis.	41,686 visits	FY15: 35,304 visits 18.1% increase
Total Pageviews	10% increase on annual basis, to be tracked on revolving quarterly basis.	162,635 pageviews	FY15: 166,991 pageviews 2.6% decrease
Average Pages per Visit	No goal, but activity should be tracked on revolving quarterly basis.	3.90 pages/visit	FY15: 4.73 pages/visit 17.5% decrease
Number of Documents Indexed	Increase by 25 documents per quarter.	3,268 documents	FY15: 2,461 documents +807 documents; 249 MRE, 469 wind
Number of External Websites Linked to <i>Tethys</i> (3+ links)	No goal, as this is outside of our control, but active outreach may increase.	94 domains	FY15: 82 domains +12 domains
Number of Websites Linked from <i>Tethys</i>	Increase by 10 links per quarter.	3,673 links	FY15: 2,907 external links +766 links
Percentage of Valid Links in <i>Tethys</i>	90% working links at any time.	This number varies by quarter based on the number of broken links, but was never less than 90%. Any broken links are fixed during this quarterly check.	

Two proxy measures that assess inherently subjective goals for *Tethys* are also included. In the absence of quantifiable goals, the PNNL team provides examples to evaluate the success of these metrics. The goals and their outcomes are described in Table 5.

Table 5. Proxy Metrics for FY16.

Metric	Definition	Goal	Outcome
Increase functionality and usefulness of site	Proxy measure - <i>Tethys</i> should constantly be adding and enhancing functionality based on community feedback.	Continued improvements annually; determined by annual peer review of 4-6 individuals. Continued improvements in the site, based on responses to spot surveys.	Peer review feedback was overall very positive from a total of 24 reviewers. There were very few concerns about inability to search content. <i>Tethys</i> is widely mentioned as being useful and functional in conference presentations, reports, and articles, highlighting the worldwide use and acceptance of the site.
Availability of information useful to users	Proxy measure - This perception is based on how well users can navigate <i>Tethys</i> , how clean the information appears, how much information is available, and more. Ratings, comments, and direct feedback may be used as an indicator when available.	The majority of site users are satisfied with the information they retrieved from <i>Tethys</i> .	An addition of 805 documents and 766 external links highlight the success of the collection effort put forth by the <i>Tethys</i> content team. The 72 respondents from the Survey Monkey rated their experience as an average 4.03 out of 5.

3.2 FY16 Highlights and Key Findings

- The most significant spike in visits was during the week of April 25-29, which coincided with the METS and IMREC conferences, in addition to the LINC webinar. During this peak, there was an average of 279 visits, compared to an average 114 visits for the rest of the year, a 145% increase.
- The average bounce rate was a low 12.5%, meaning 87.5% of users continued beyond the first page they landed on. Google Analytics benchmarks averages for “content websites” at 40-60%. Therefore, *Tethys* is successfully attracting users who are interested in the content and continue to explore the content.
- Over 53% of traffic comes from search engines (primarily Google), another 32% of traffic comes from bookmarked pages or and document links, and 14% of traffic comes from other websites. These statistics tell us where to focus our efforts to improve usage numbers.
- The significant increase of 766 links was largely due to new organization landing pages on *Tethys*. We now have 1,188 organizations in *Tethys*, each page providing basic information and listing all other documents in *Tethys* by that organization.
- Geotagged content on the Map Viewer was increased from approximately 700 documents to 2,120 documents, a 300% increase. This was mostly accomplished by geotagging existing documents that referenced a location.
- Additional *Tethys* features developed over the last year include:

- The home page was redesigned with a fresh look and feel: providing better visuals to represent the content, equally representing wind and MRE, providing more intuitive entry points to explore *Tethys*, and more.
- Wind and MRE content on the Knowledge Base and Map Viewer were clearly separated out, allowing users to select what content they are interested in from the loading screen, and allowing users to save their preference to their account.
- Videos are now mounted on YouTube (although found on *Tethys*) to reduce data usage on *Tethys* and to ensure video compatibility for all users.
- The curation of Annex IV metadata forms was updated with a process that automatically sends out requests for updates every 12-18 months. An internal view was also created to better show the status of forms and allow update requests with the click of a button.
- An end-of-the-year push to improve speeds across the site is currently underway, focusing on the Map Viewer and Knowledge Base.
- A new *Tethys* Blast was released every other Friday morning during FY16, for a total of twenty-seven *Tethys* Blasts. The list for *Tethys* Blast dissemination grew from 801 to 1,027 individuals, a growth of 226 new subscribers over the year.
- Eight *Tethys* stories were released during FY16.
- Social media has been used primarily to announce webinars and *Tethys* stories. The Facebook page currently has 135 likes (+25 since FY15) and the Twitter account has 215 followers (+63 since FY15).

3.3 Google Analytics for FY16

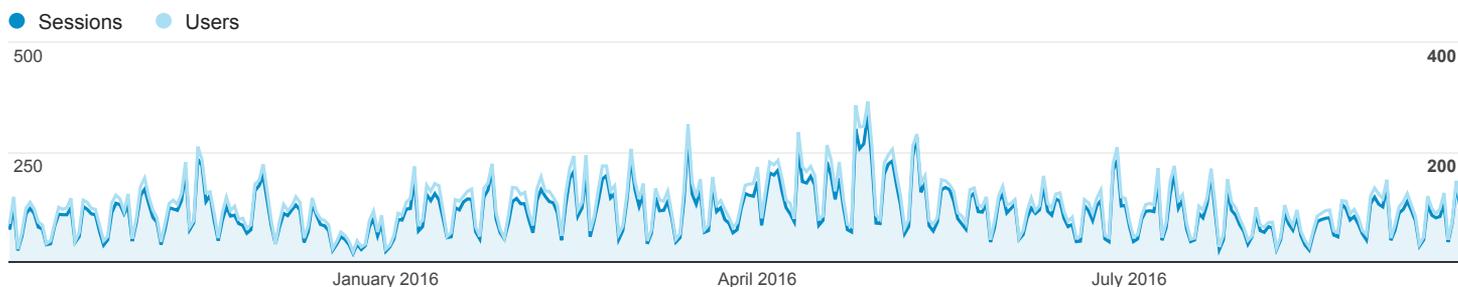
The following several pages are a direct output of annual statistics from Google Analytics, showing information that may prove helpful in identifying the audience of *Tethys* and top referral sources:

Printout for U.S. Department of Energy

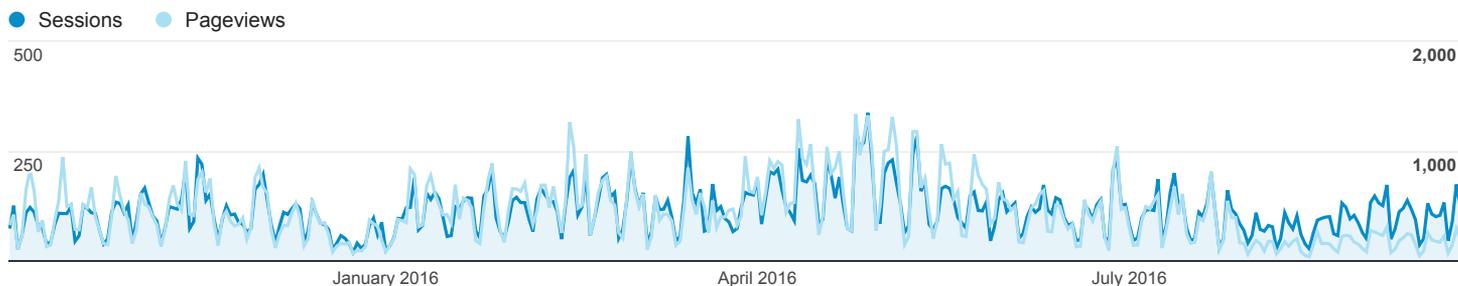
Oct 1, 2015 - Sep 20, 2016

Exclude PNNL
63.02% Sessions

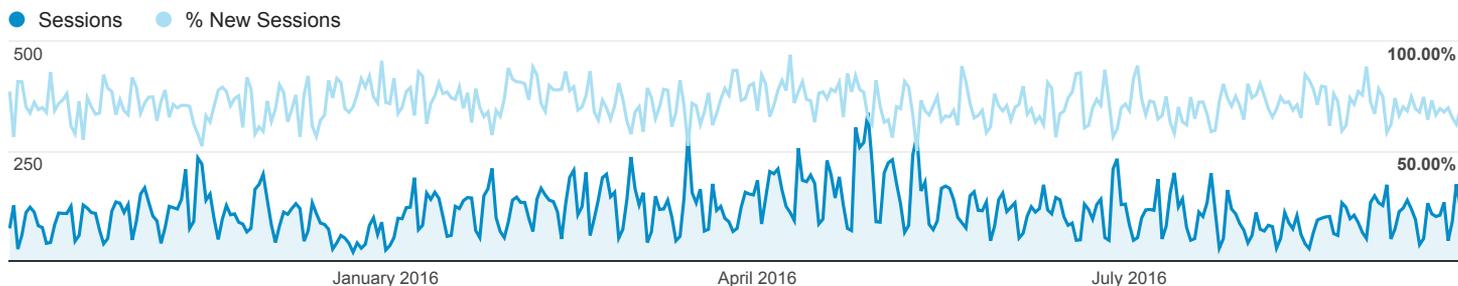
Sessions and Unique Visitors



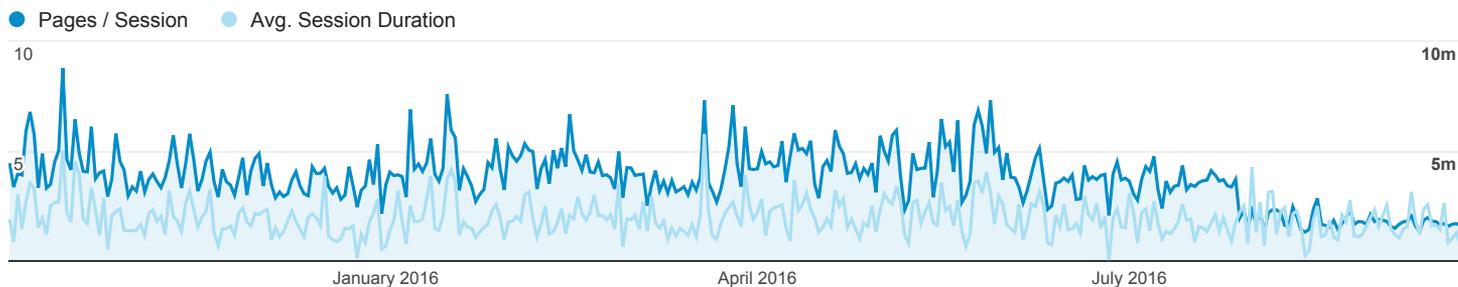
Sessions and Pageviews



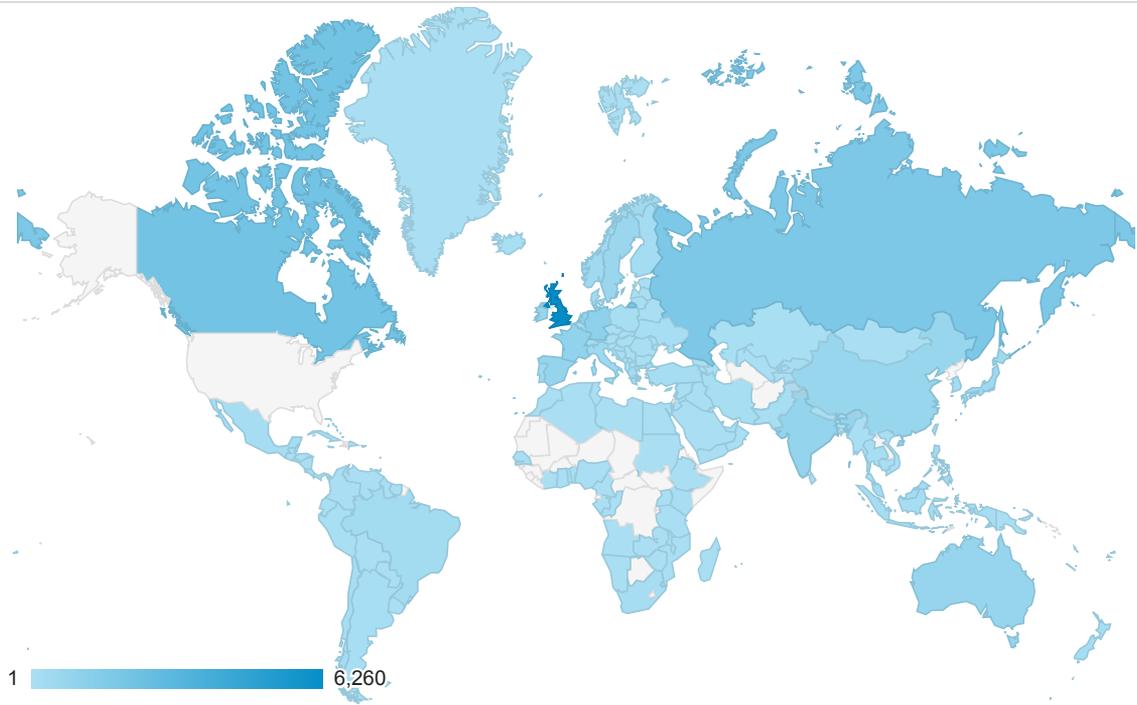
Sessions and % New Sessions



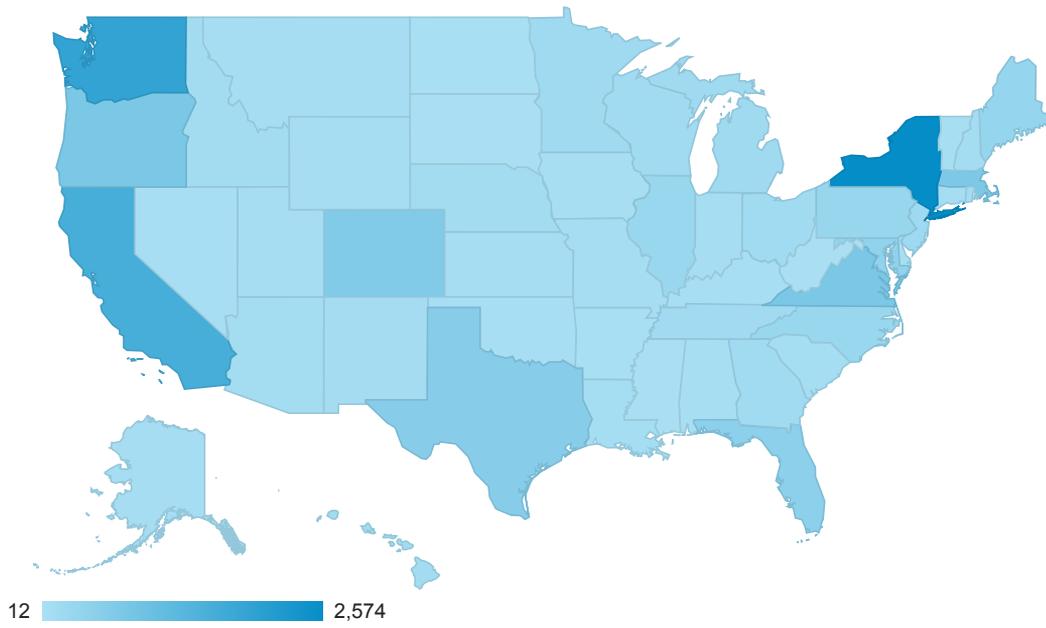
Pages / Session and Avg. Session Duration



Visits Per Country (excluding the U.S.)



Visits Per State



Sessions and Bounce Rate by Source / Medium

Source / Medium	Sessions	Bounce Rate
google / organic	19,513	9.34%
(direct) / (none)	12,884	6.15%
bing / organic	1,314	8.30%
rank-checker.online / referral	736	98.10%
en.wikipedia.org / referral	598	8.36%
site-auditor.online / referral	510	98.43%
yahoo / organic	510	7.45%
links.govdelivery.com / referral	454	2.42%
energy.gov / referral	404	4.70%
monetizationking.net / referral	315	98.10%

Sessions and Bounce Rate by Page

Page	Sessions	Bounce Rate
/	6,150	36.73%
/user/register	1,954	0.15%
/annex-iv-sites/la-rance-tidal-barrage	1,131	10.79%
/publications/state-of-the-science-2016	947	6.34%
/publications/san-juan-islands-tidal-currents	825	17.45%
/technology-type/wave	595	8.40%
/about-wren	477	15.09%
/annex-iv-sites/sihwa-tidal-power-plant	464	9.27%
/technology-type/tidal	463	8.42%
/events/mid-atlantic-baseline-study-webinar	424	0.00%

Appendix A: Plan for Speeding up *Tethys*

August 2016

Problem Statement

The relative and actual load speeds and transition speeds for *Tethys* pages has slowed as the website has grown in size, resulting in unacceptable load speeds for certain platforms and operating systems. As growth continues, it is likely that the site will slow more. Speeds can be assessed by benchmarking tests and average load times tracked with Google Analytics.

Goal

The goal is to increase the load speeds and transitions for *Tethys*, particularly for the Knowledge Base and Map Viewer.

Approach

Initial analysis of *Tethys* in its present form indicates that the Knowledge Base (KB) and Map Viewer (MV) are responsible for the vast majority of all slow down and loading challenges. All other portions of *Tethys* are static, load small amounts of content, or link to outside material rapidly. Coupled with the central importance of the KB and MV to the usability of *Tethys*, the process for speeding up *Tethys* will concentrate initially on the KB and MV. Later, some small improvements will be identified with Google's "PageSpeed Insights" tool to improve speeds across the entire site.

Testing Mechanisms

The speed of *Tethys* and its component parts will be assessed through benchmarking tests and tracking average load times, using Google Analytics.

Insights from PageSpeed

Using the PageSpeed by Google tool, we will analyze all of *Tethys* to obtain specific additional suggestions for improvements. These suggestions may include reduction of image sizes to web standards, compaction of code, leverage of browser caching, and elimination of problematic code. Suggestions that are highlighted by PageSpeed may be specific to a given page (e.g., the home page), while others may be applicable to the entire site.

Testing and Iteration

Each optimization step (discussed below) requires testing across *Tethys* to ensure that the desired results have been achieved and that no unanticipated functional changes have occurred, and that no threats to the integrity of the site are likely to follow. This needs to be an iterative, continuous process.

Optimizing Process – Knowledge Base

Caching of Content

Each time a user requests a set of documents from the *Tethys* KB or MV using filters or search criteria, this query has to search all existing documents to find results to display. Caching will save the results of past queries on the server, resulting in considerable speed increases for retrievals by the next user. Even the initial load of the KB or MV can be cached. To ensure that the cached content continues to reflect all documents in the KB and MV, the cache is reset every time a document is added or changed.

Additionally, the cache will be regenerated every 4 days even if no changes are made.

Reducing Process Runtime

Though caching can significantly reduce load times on saved queries, a user who makes a unique query, or is the first to initiate a query after the cache has been reset, will also benefit from speed increases. These new queries involve a process of filtering, concatenating, and sorting of data to generate the display. By making this processing more efficient, each load speed will be increased.

Minimizing the Size of Queries

Currently the *Tethys* KB loads all entries at one time onto a single page that displays more content as you scroll down (scroll loading). Processing time can be drastically decreased by changing from scroll loading to pagination, where only a page's worth (100 documents) is loaded at a time. This method will allow users to navigate the pages below, as is common with many commercial websites. New queries will still be assessed across all documents rather than just the 100 being displayed on the page.

Optimizing Code

Although *Tethys* is built on a Drupal system and adheres to the template and rules of Drupal, there is considerable coding needed to customize the site to achieve the desired outcomes. There are frequently options for optimizing code to reduce processing time and duplication of effort. Efforts will be made to optimize code throughout the site.

Optimizing Process – Map Viewer

The process of optimizing the MV will follow the same steps as used for the KB. In addition, the underlying technology used for creating the clusters and the underlying map will be reconsidered to determine if additional efficiencies and speed can be realized, while maintaining or improving functionality.

Additional Infrastructure and Server Layer Technologies

Once all optimization of Drupal has been achieved, we will examine the use of alternative server organization and associated infrastructure to further optimize *Tethys*.



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