Oceans of Data Institute: Integrating Data Literacy into Science Education

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Oceans of Data Institute
Education Development Center, Inc.

Presented at the Cutting Edge Digital Data Workshop
May 13, 2015

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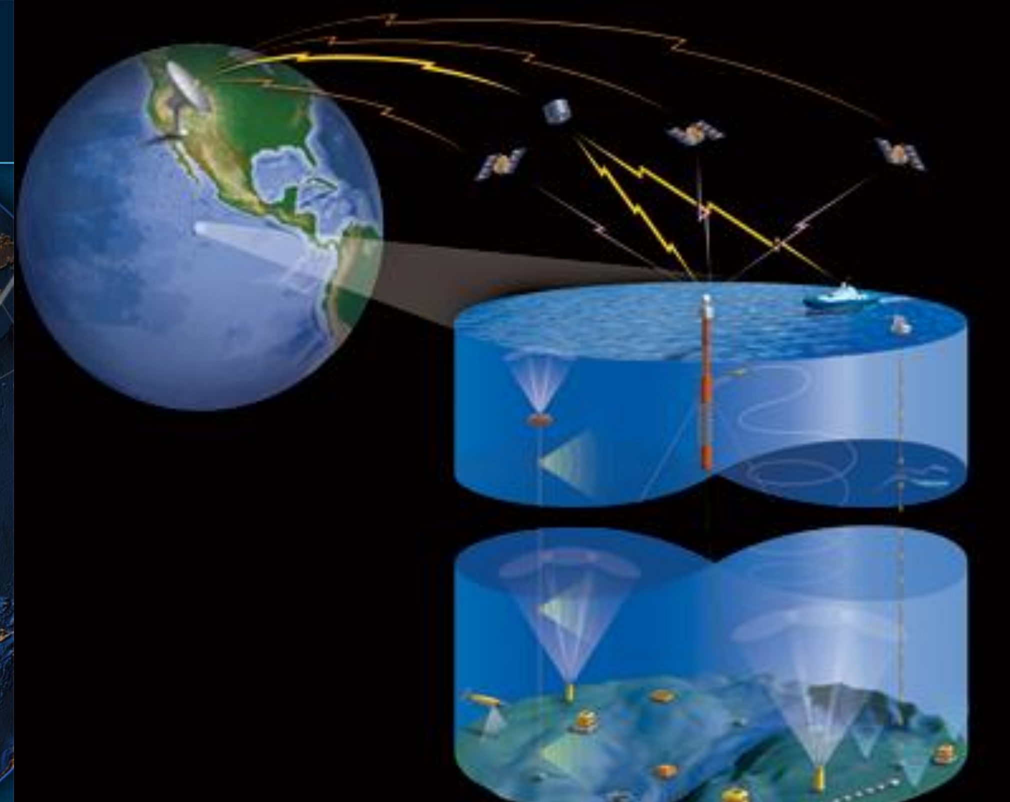
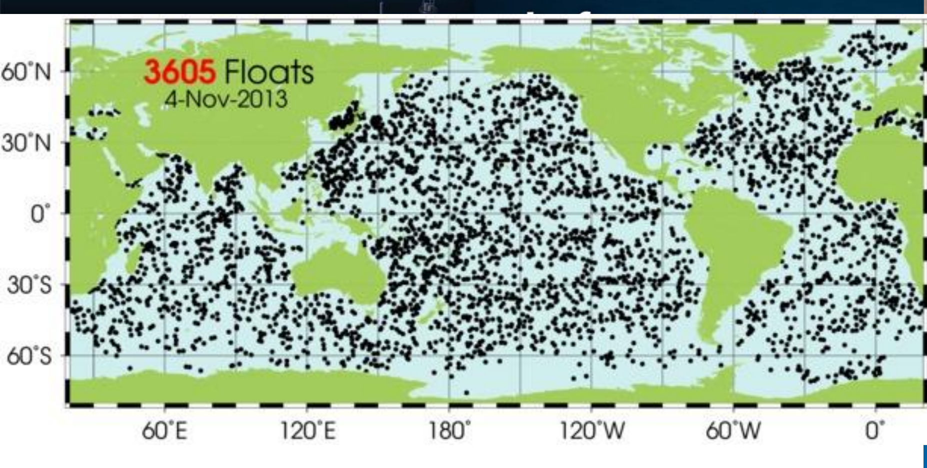
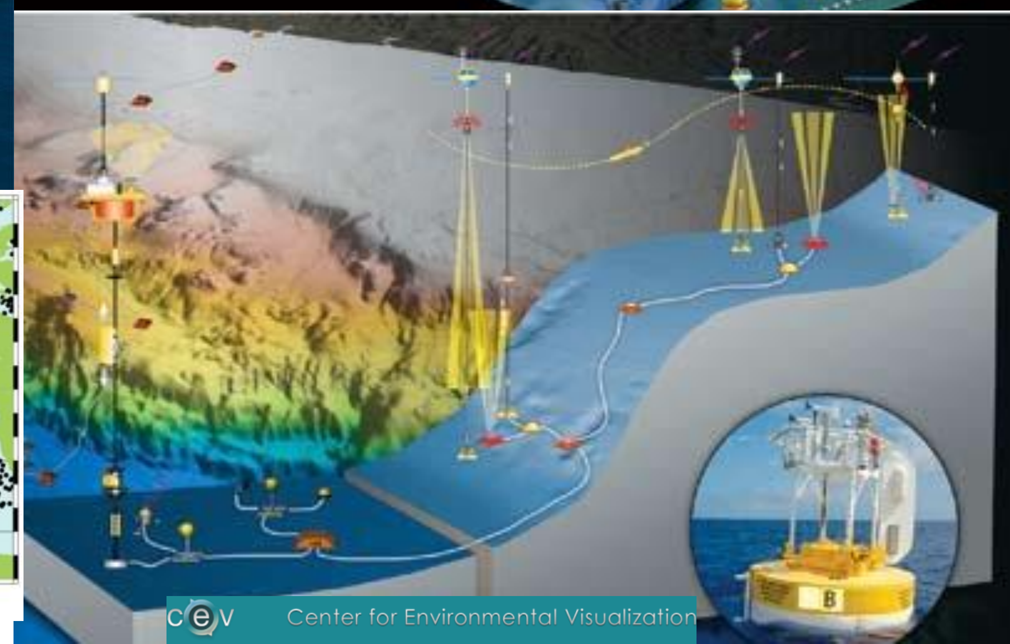
CYBER- INFRASTRUCTURE







Working with data is important in the workforce well beyond science!

Steve Ross
Broadband Communities Magazine

Juan Miguel Lavista Ferres
Bing/Microsoft

Tim Chadwick
Dynamic Network Services, Inc.

Ryan Kapaun
Eden Prairie Police Department

Shannon McWeeney
Oregon Health & Science University

Randy Bucciarelli
Scripps Institution of Oceanography
UC San Diego

Kartik Shah
Strategix Solutions

Benjamin Davison
Google

Lucy Drotning
Columbia University

Kirk Borne
George Mason University

Jay Parker
Jet Propulsion Laboratory
California Institute of Technology

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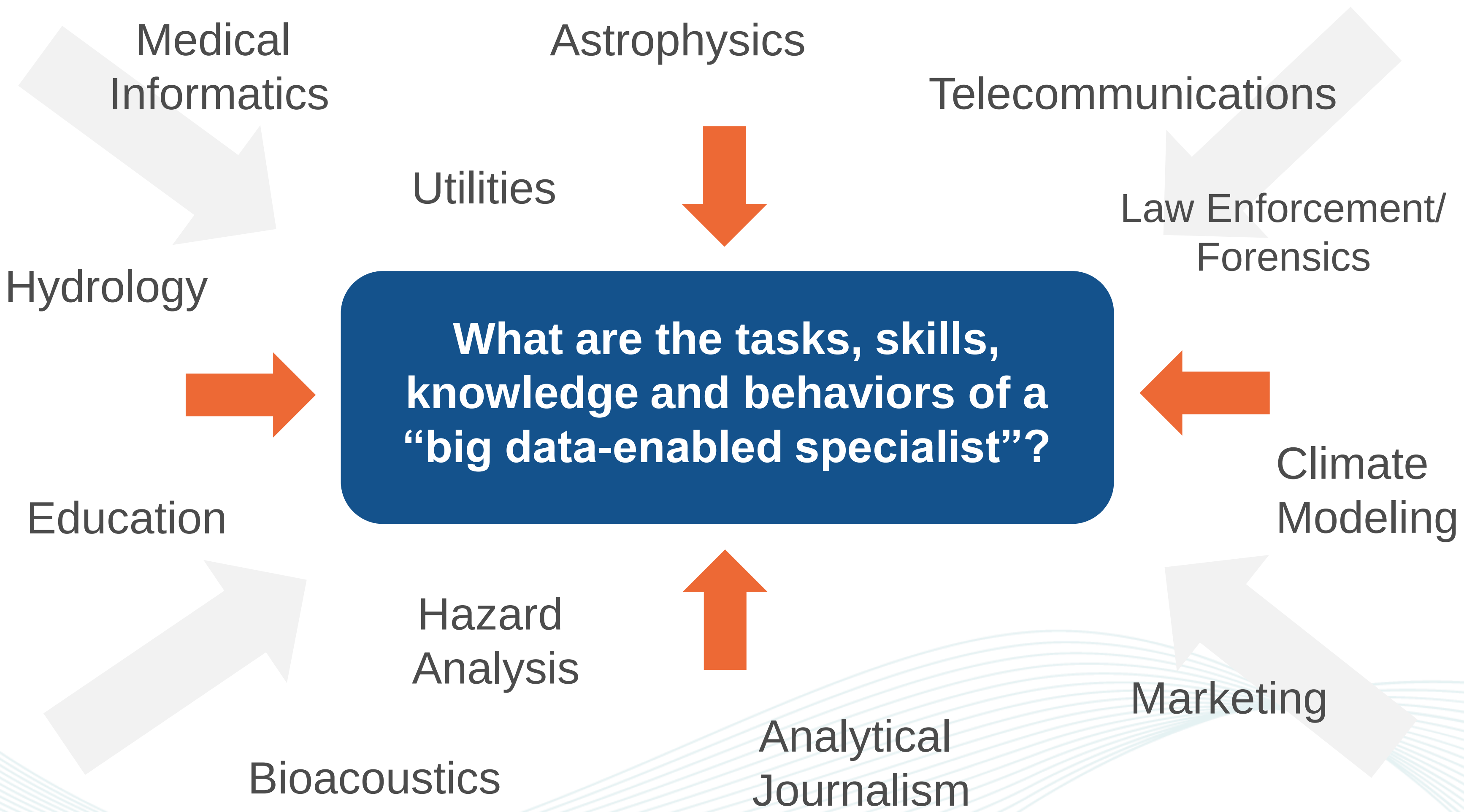
Developing an Occupational Profile



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The Big Data Enabled Specialist is an individual who wrangles and analyzes large and/or complex data sets to enable new capabilities including discovery, decision support and improved outcomes.

Major work responsibilities- Duties

1) Defines the problem
2) Wrangles data
3) Manages data resources
4) Develops methods and tools
5) Analyzes data
6) Communicates findings
7) Engages in professional development

What are the skills, knowledge and behaviors of a "big data-enabled specialist"?

As identified by an expert panel of big data users, and verified by ~150 big data users:

Skills:

- Analytical Thinking (96%)
- Critical Thinking (84%)
- Problem-solving (75%)
- Applying Statistical Methods (74%)
- Data Manipulation (70%)

Knowledge:

- Analytic Thinking (89%)
- Algorithms (e.g., machine learning, statistics) (76%)
- Data Modeling (70%)
- Data Structures (70%)
- Best Practices (69%)
- Statistics (69%)

Behaviors:

- A problem solver (89%)
- A lifelong learner (78%)
- Willing to question (78%)
- A seeker of patterns (67%)
- Open-minded (67%)

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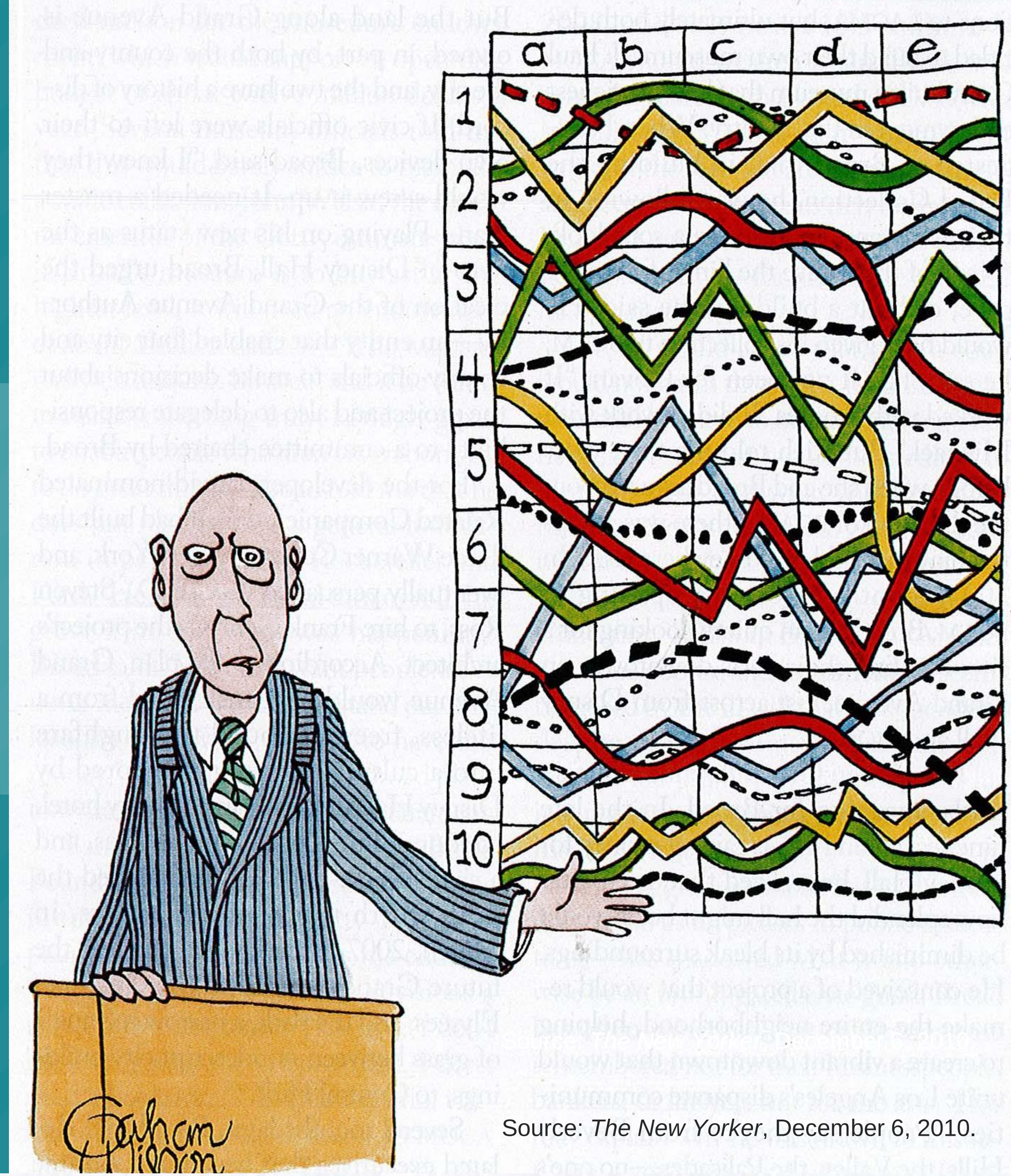
Students recognize the importance of data literacy

The Oceans of Data Institute surveyed 300+ students from community college and university settings:

- 85% of respondents agreed or strongly agreed that the ability to make sense of data is **important to get a good job and will help in their future careers**.
- 90% of respondents agreed or strongly agreed that learning to make sense of data will help them be **more effective and informed citizens**

Building students' skills in working with large, complex datasets is important.

What are the challenges?



Source: *The New Yorker*, December 6, 2010.

"I'll pause for a moment so you can let this information sink in."

Challenges

- **Schools (k-16) aren't currently developing students' data-using skills**, particularly those skills necessary to work with large, complex data sets.
- **Very little research** has been done that tells us how to develop these skills
- **Limited awareness** of the importance of ramping up the teaching of these skills

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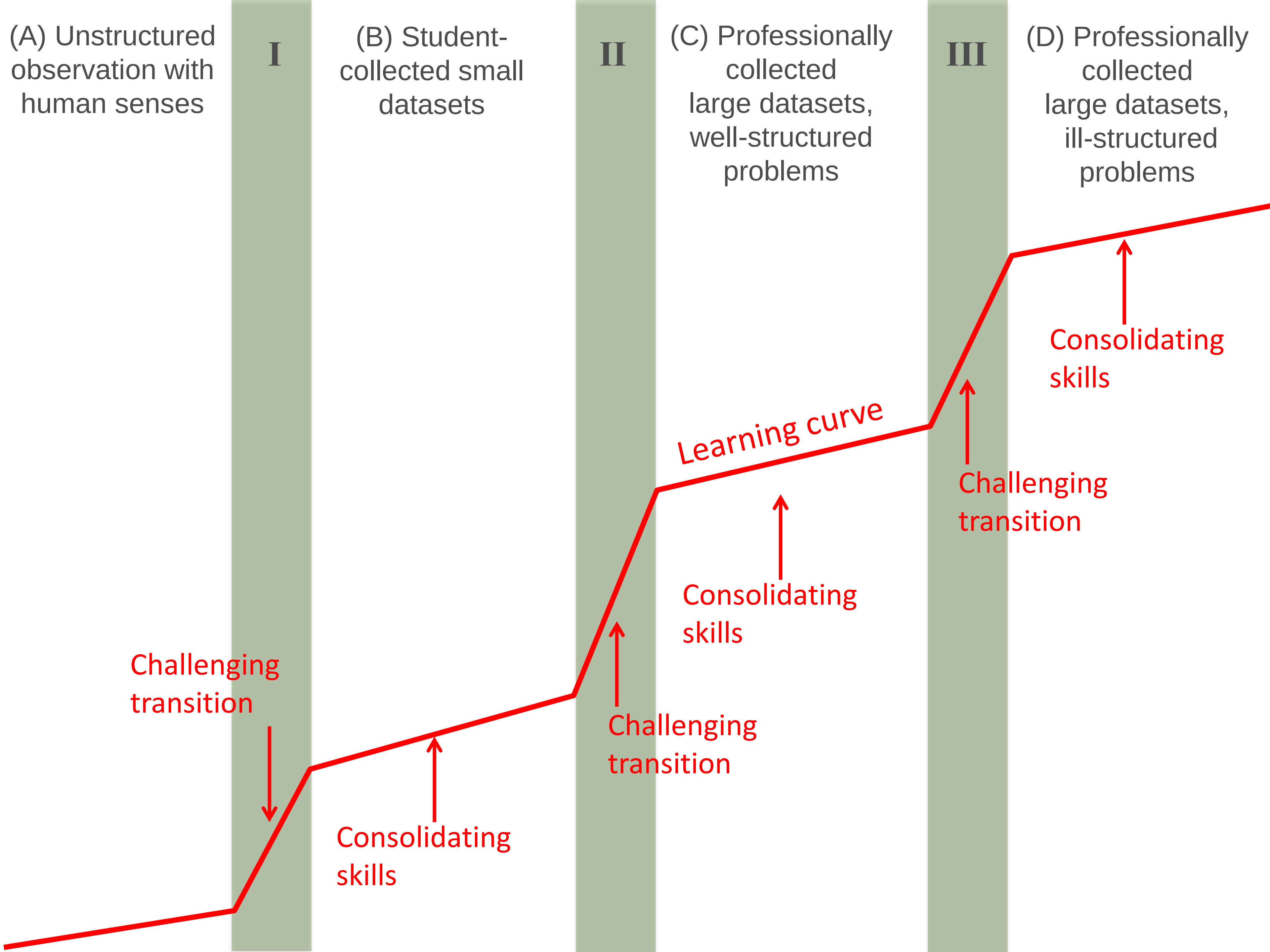

(A) Unstructured observation with human senses
I
(B) Student-collected small datasets
II
(C) Professionally collected large datasets, well-structured problems
III
(D) Professionally collected large datasets, ill-structured problems
Learning curve
Challenging transition
Consolidating skills
Challenging transition
Consolidating skills
Challenging transition
Consolidating skills

Challenging transitions

Embodied, experiential grasp of the natural setting and data collection methods

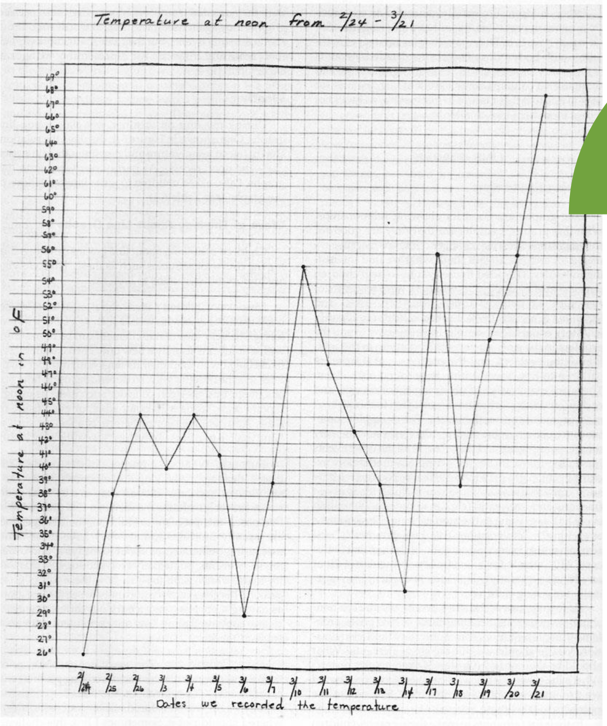
Metadata

Photo credits: (left) School in the Forest powerpoint, http://www.blackrockforest.org/docs/about-the-forest/schoolintheforest (right) Using a Digital Library to Enhance Earth Science Education, Rajul Pandya, Holly Devaul, and Mary Marlino)

Challenging transitions

Dozens of data points

Petabytes



Air temperature at noon

Date

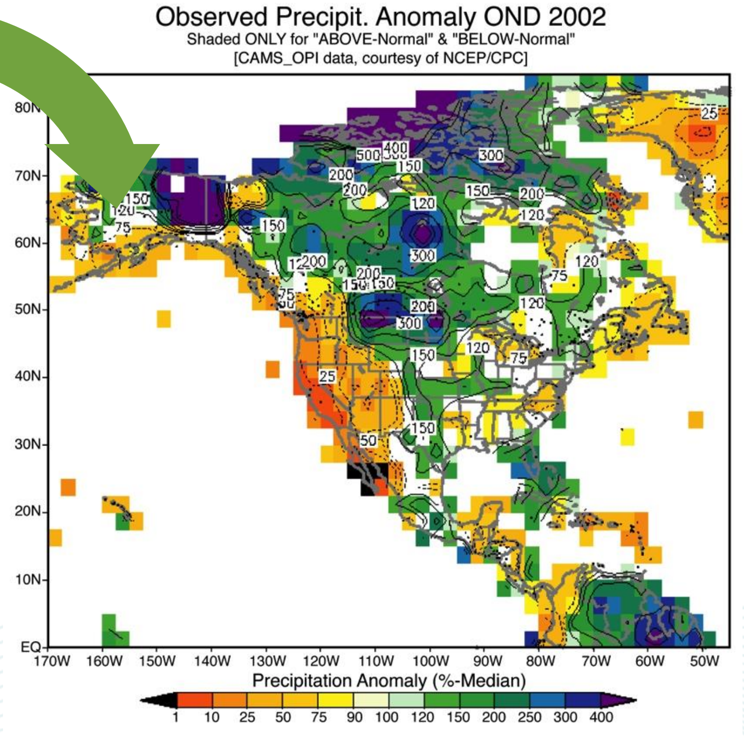


Image credits: (left) from Clement, 2002

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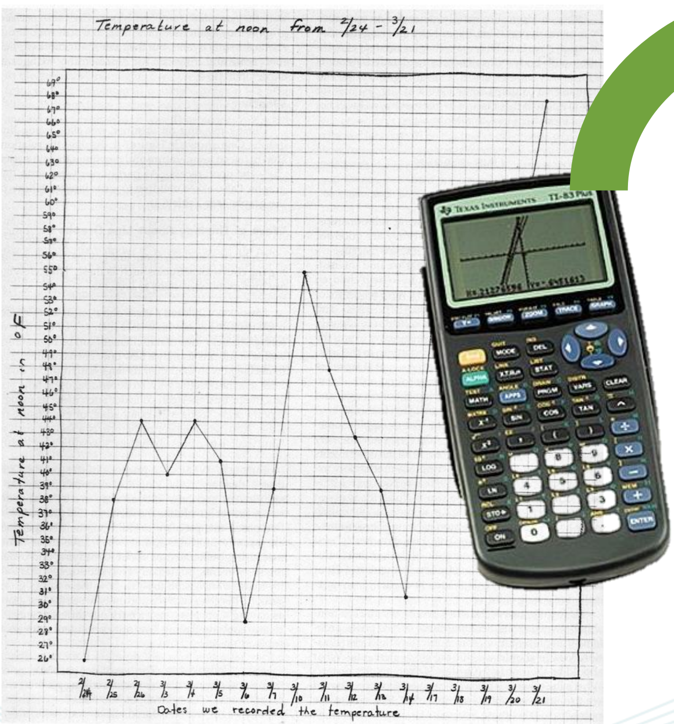
Challenging transitions

Simple, transparent tools and techniques

Sophisticated tools and techniques

Air temperature at noon



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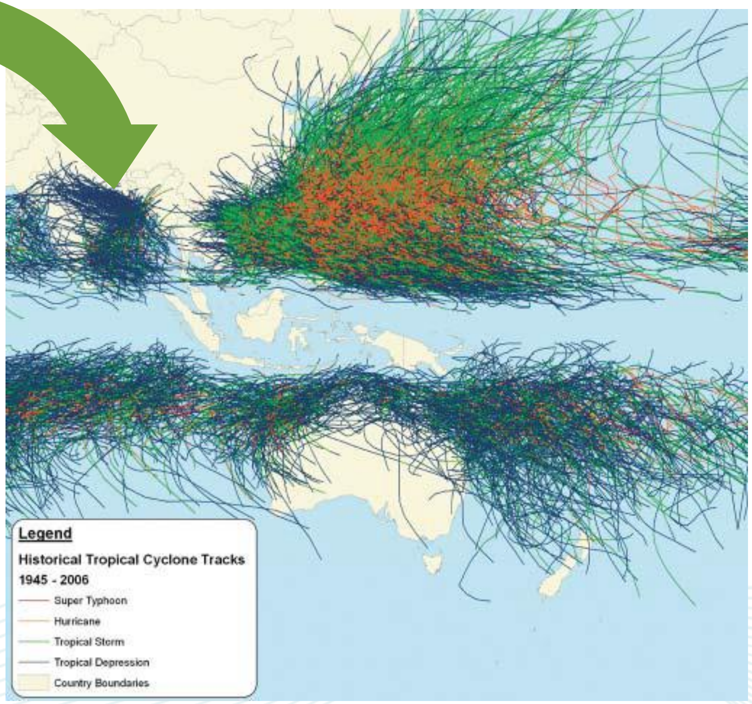
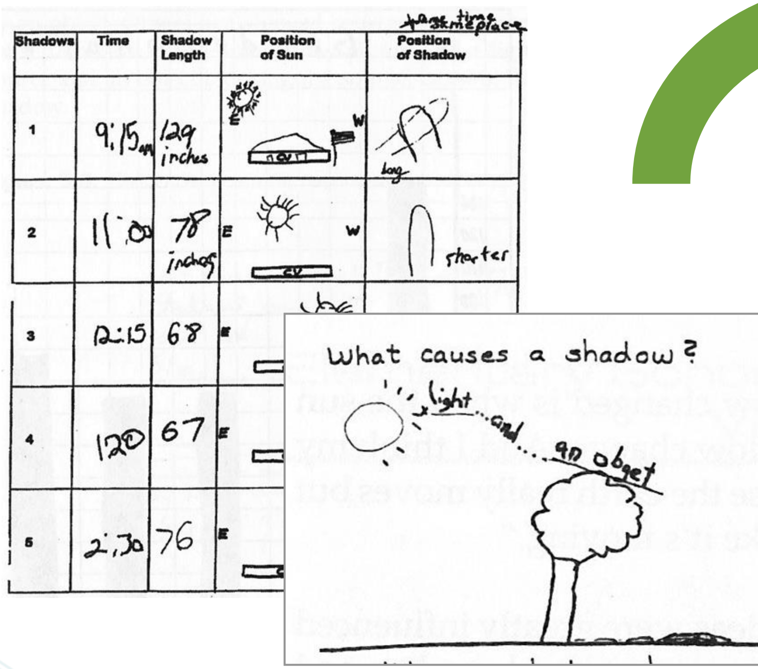


Image credits: (left) from Clement, 2002; (right) http://www.esri.com/library/ebooks/climate-change.pdf

Challenging transitions

Common sense lines of reasoning



Spatial, temporal, statistical reasoning. Multi-step chains of reasoning

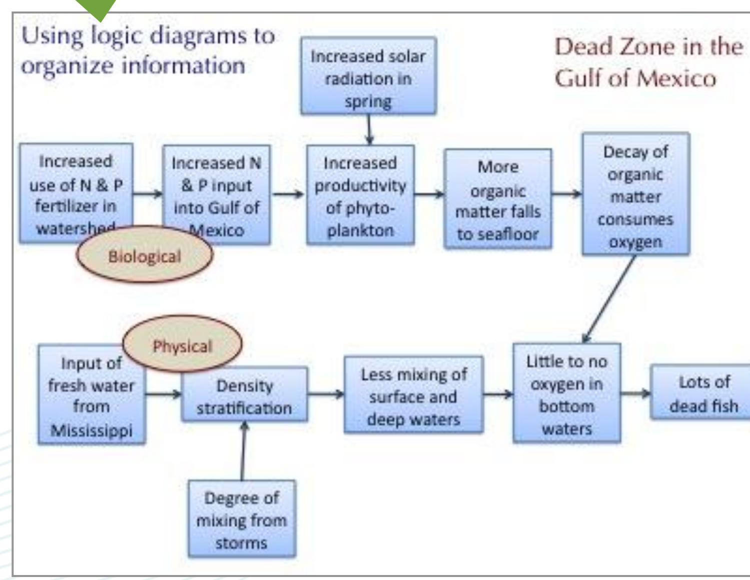


Image credits: (left) Wainwright, 2002

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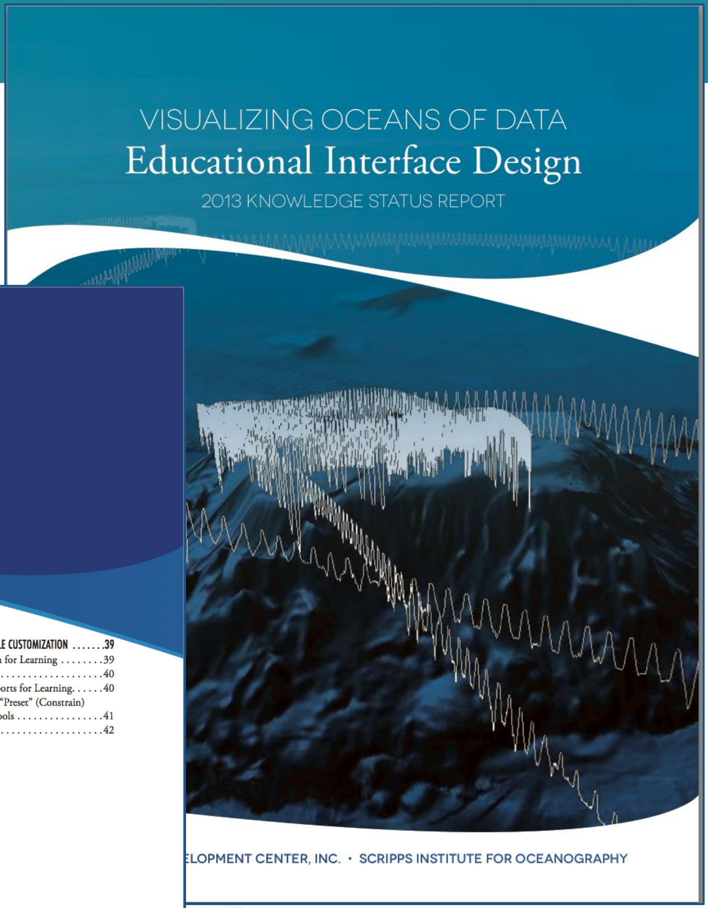
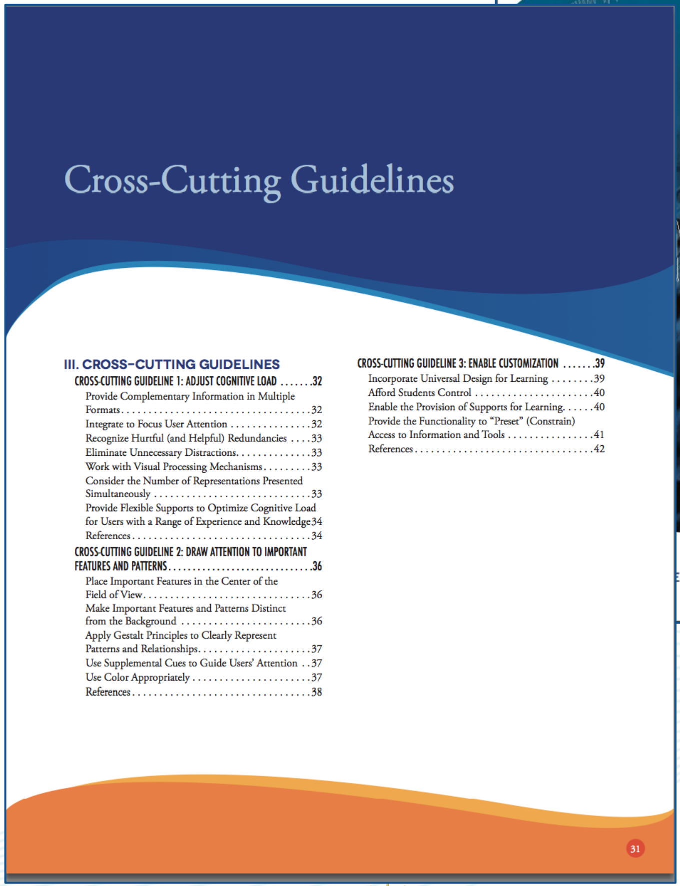
Tackling the challenges: Oceans of Data Exploratory Project

In what ways can knowledge from diverse disciplines inform the design of interfaces and technology tools to be used by students accessing large scientific databases?





Cross-Cutting Guidelines

31

Bridging interfaces built for scientists to novice users

- Expert data access and data representations may be baffling to students
- No coherent body of knowledge about how to design student-friendly data interfaces and data analysis tools

What we did: reviewed/coded literature

- Annals of the Association of American Geographers
- Applied Cognitive Psychology
- Behavior and Information Technology
- The Cartographic Journal
- Computers in Human Behavior
- Contemporary Educational Psychology
- Educational Studies in Mathematics
- Ergonomics
- European Journal of Psychology and Education
- Geoforum
- Geographical Research
- Instructional Science
- Journal of the American Statistical Association
- Journal of Computing in Higher Education
- Journal of Educational Psychology
- Journal of Experimental Psychology: General
- Journal of Experimental Psychology: Learning, Memory, and Cognition
- Journal of Geography
- Journal of the Learning Sciences
- Journal of Research in Mathematics Education
- Journal of Science, Education and Technology
- Learning and Instruction
- Professional Geographer
- Review of Educational Research
- Science
- Science Education
- Technical Communications Quarterly
- Technology Innovations in Statistics Education
- Technology, Pedagogy and Education

What we did: consulted experts

Oceans of Data Advisory Board

Yi Chou, Principal Scientist, Jet Propulsion Laboratory

Daniel Edelson, Vice President of Education, National Geographic

William Finzer, Senior Scientist, KCP Technologies

Allison Fundis, Research Scientist and Education and Public Outreach Liaison, Oceans Observatories Initiative RSN, University of Washington

Boris Goldowsky, Director of Technology, Center for Applied Special Technology

James Hammerman, Senior Researcher & Evaluator, TERC

Kim Kastens, Doherty Senior Research Scientist, Lamont-Doherty Earth Observatory, Columbia University

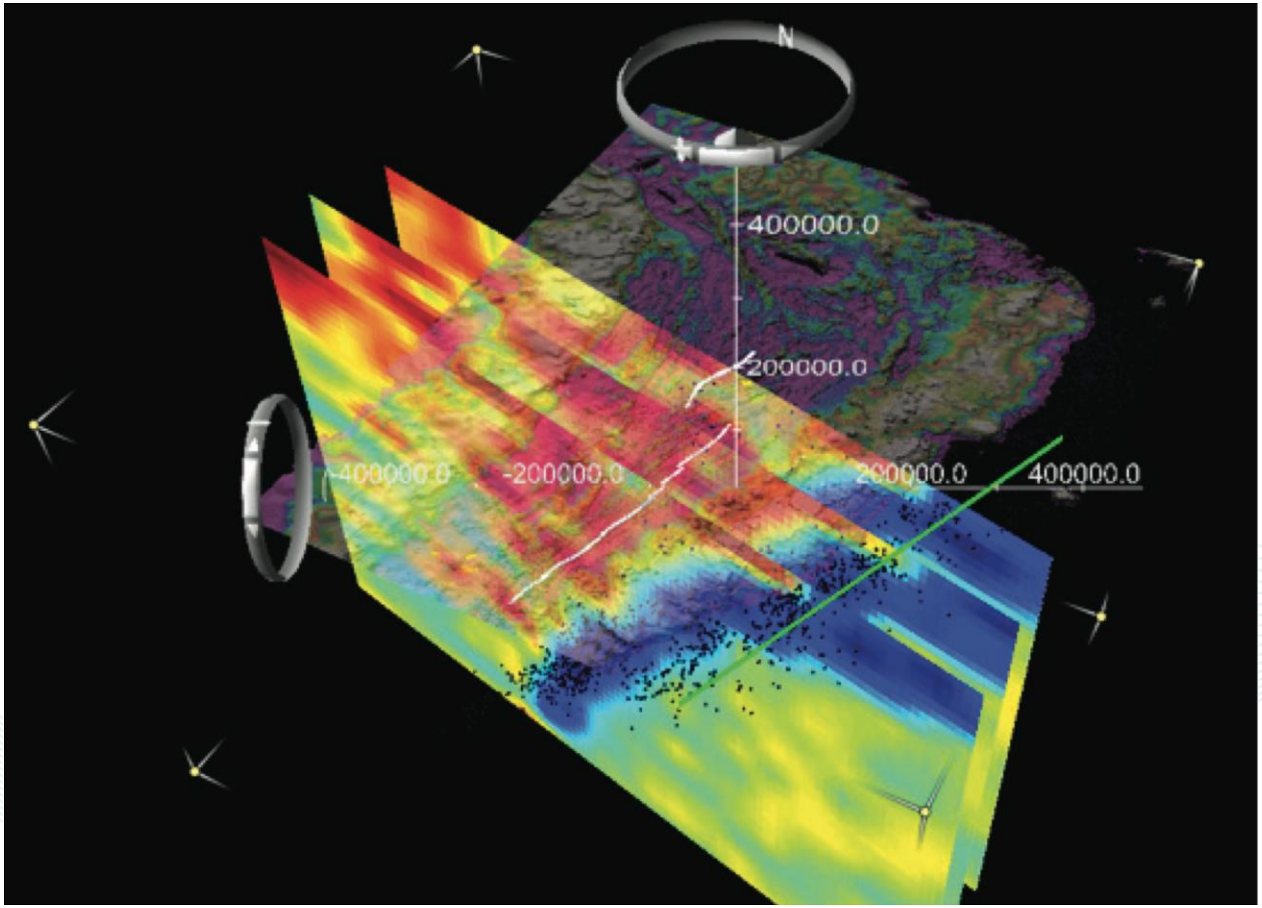
Julianne Mueller-Northcott, Biology and Earth Science Teacher, Souhegan High School, Amherst, NH

John Orcutt, Professor of Geophysics, Scripps Institution of Oceanography, UCSD

William Sandoval, Associate Professor of Psychological Studies in Education, Graduate School of Education and Information Studies, UCLA

What we've learned

What an expert sees on a data access page or in a visualization will not be what a novice sees



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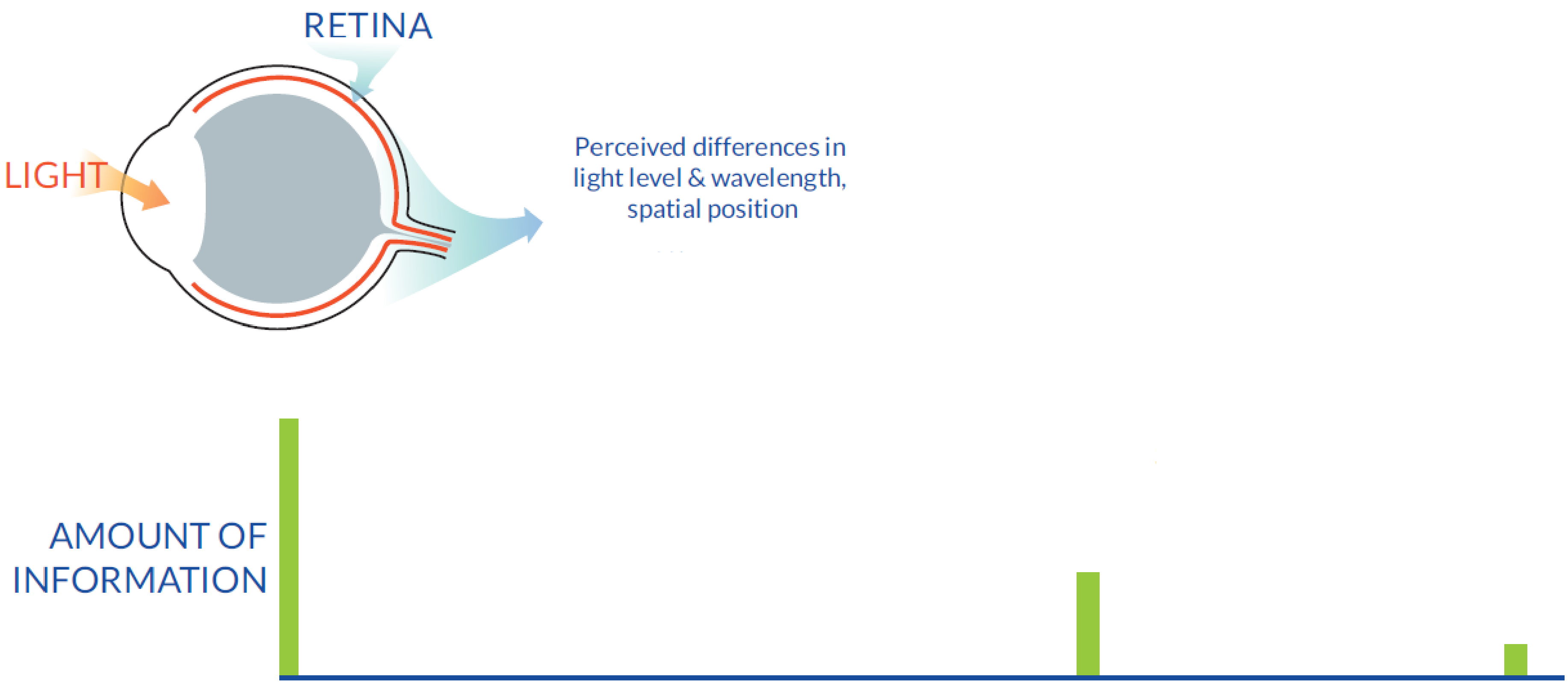
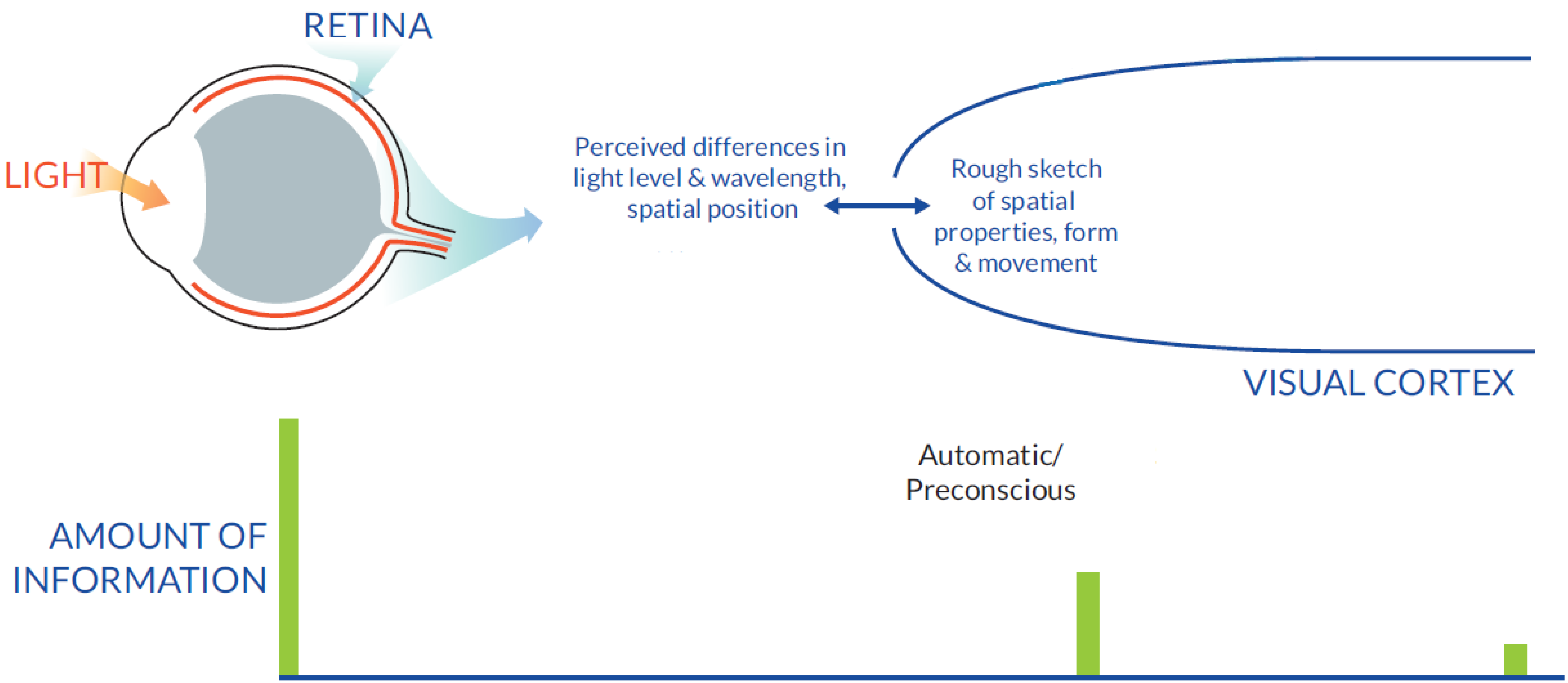
Visual perception = information processing



A simplified diagram of the information-processing performed by the human visual system.

Visual perception = information processing



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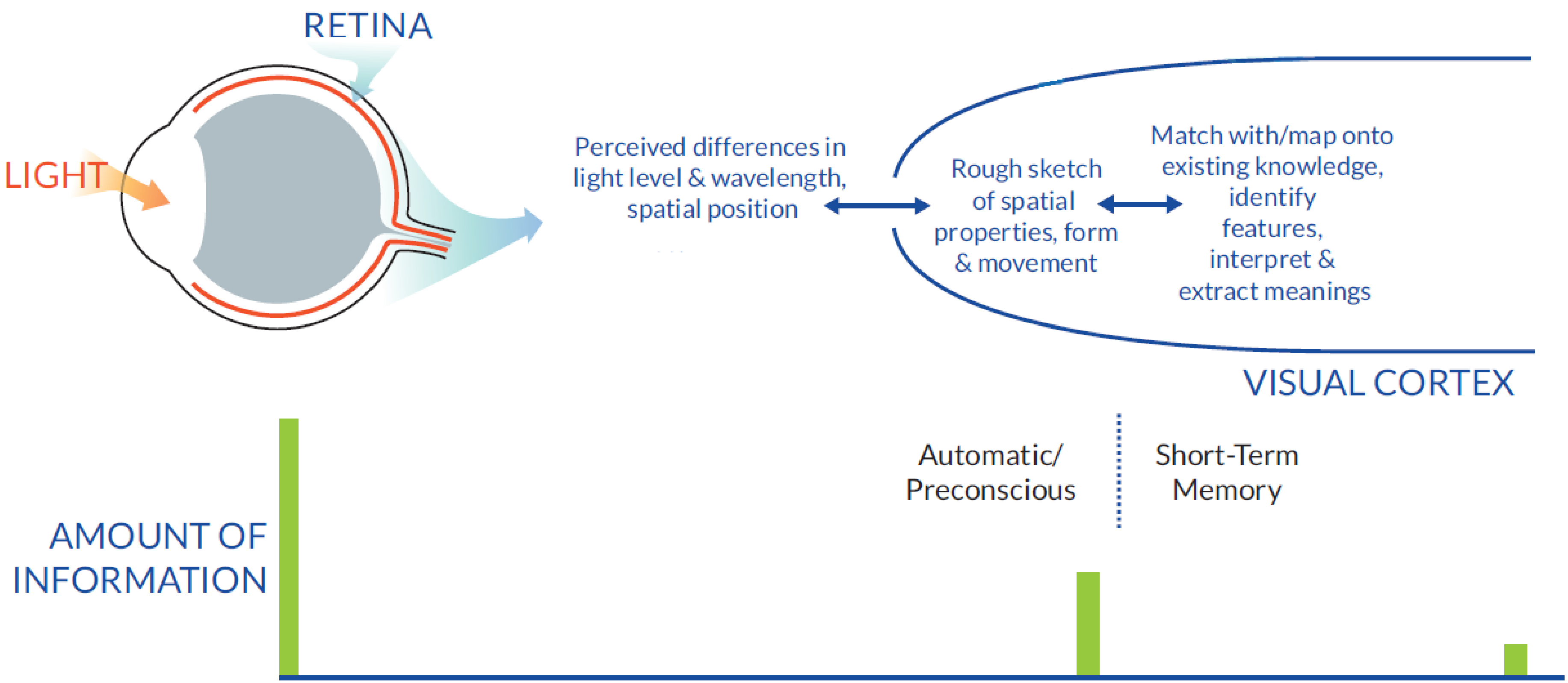
Visual perception = information processing



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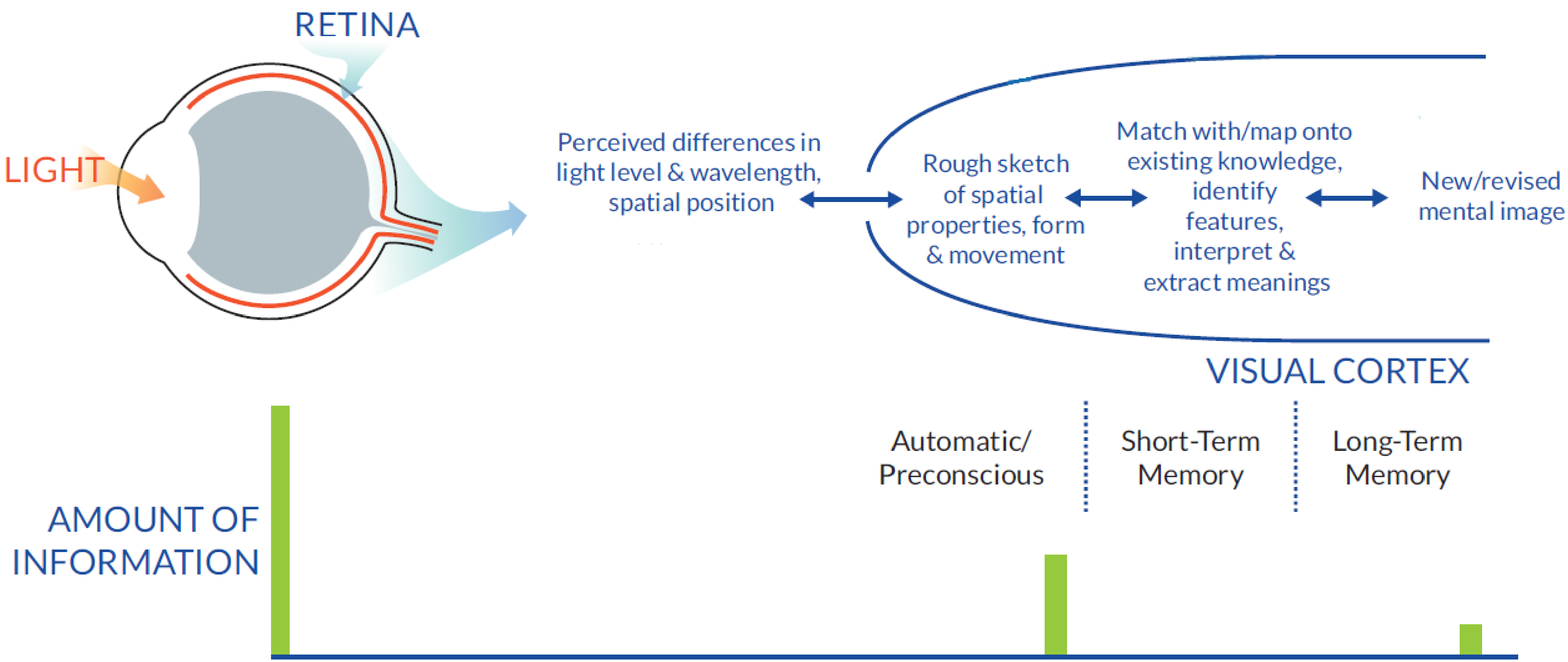
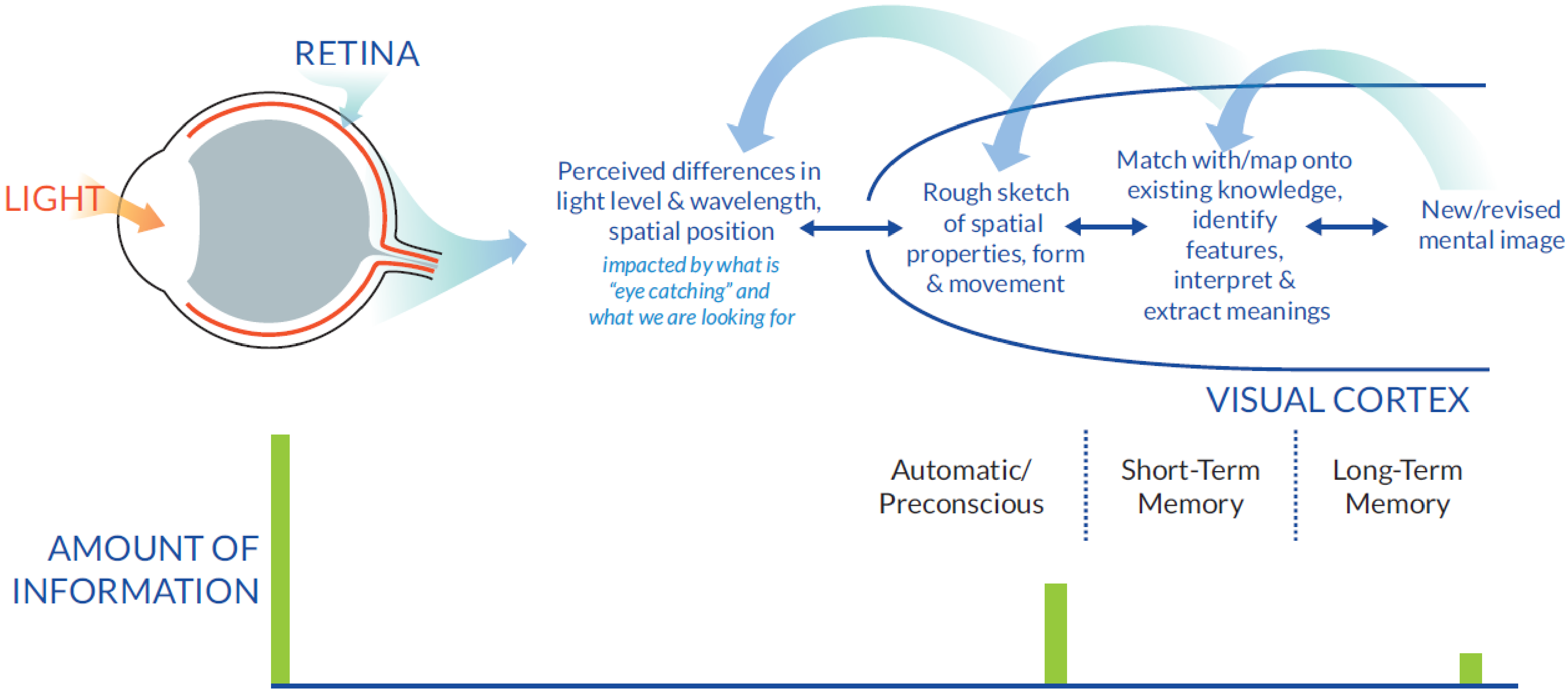
Visual perception = information processing



A simplified diagram of the information-processing performed by the human visual system.

Visual perception = information processing



A simplified diagram of the information-processing performed by the human visual system.

Adjust Cognitive Load

Short-term (working) memory – limited capacity

Intrinsic Cognitive Load	Germane Cognitive Load	Extraneous Cognitive Load

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Adjust Cognitive Load

Short-term (working) memory – limited capacity

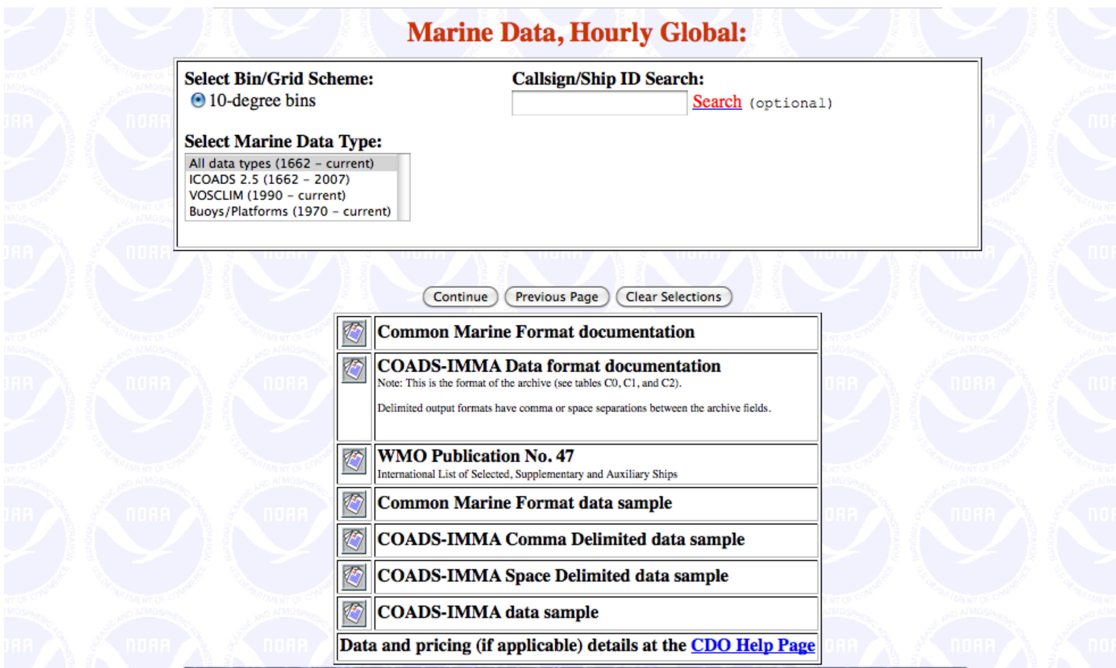
Intrinsic Cognitive Load

Germane Cognitive Load

Extraneous Cognitive Load

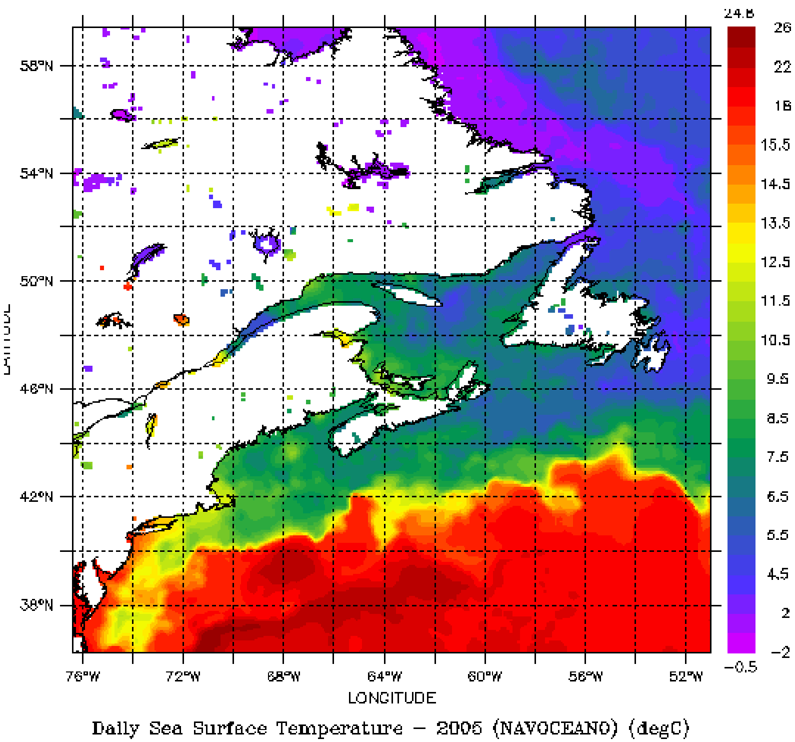
Accessing and visualizing data should be fast and easy

- There should be low to no barriers to downloading and visualizing a data set
- Minimize expert terminology
- Automate processes not important to the learning goals

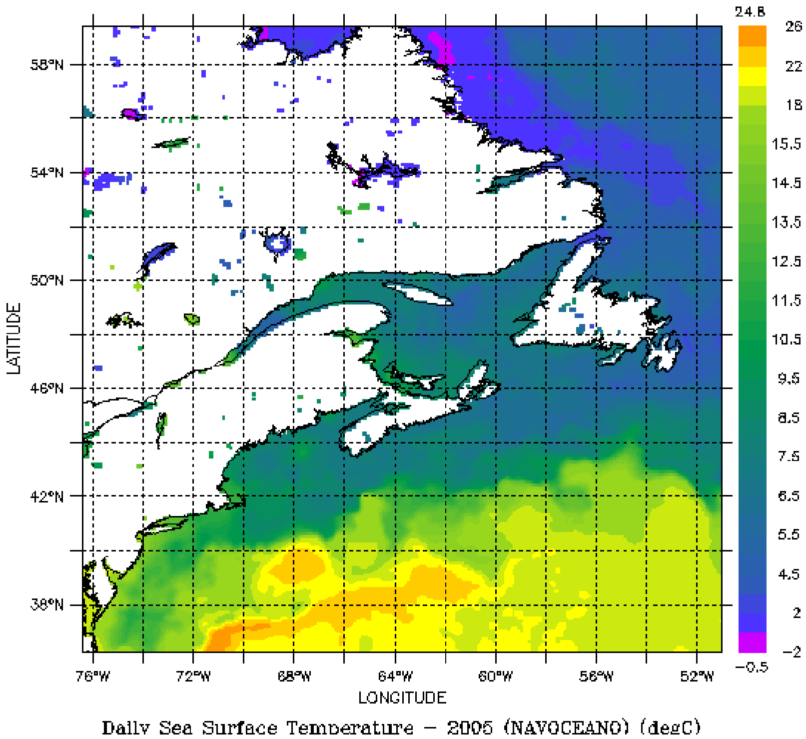


http://www7.ncdc.noaa.gov/CDO/CDOMarineSelect.jsp

- **Include information to minimize confusion**
- **Make the important information stand out**



Default color palette



Alternative color palette

Source: http://mynasadata.larc.nasa.gov/

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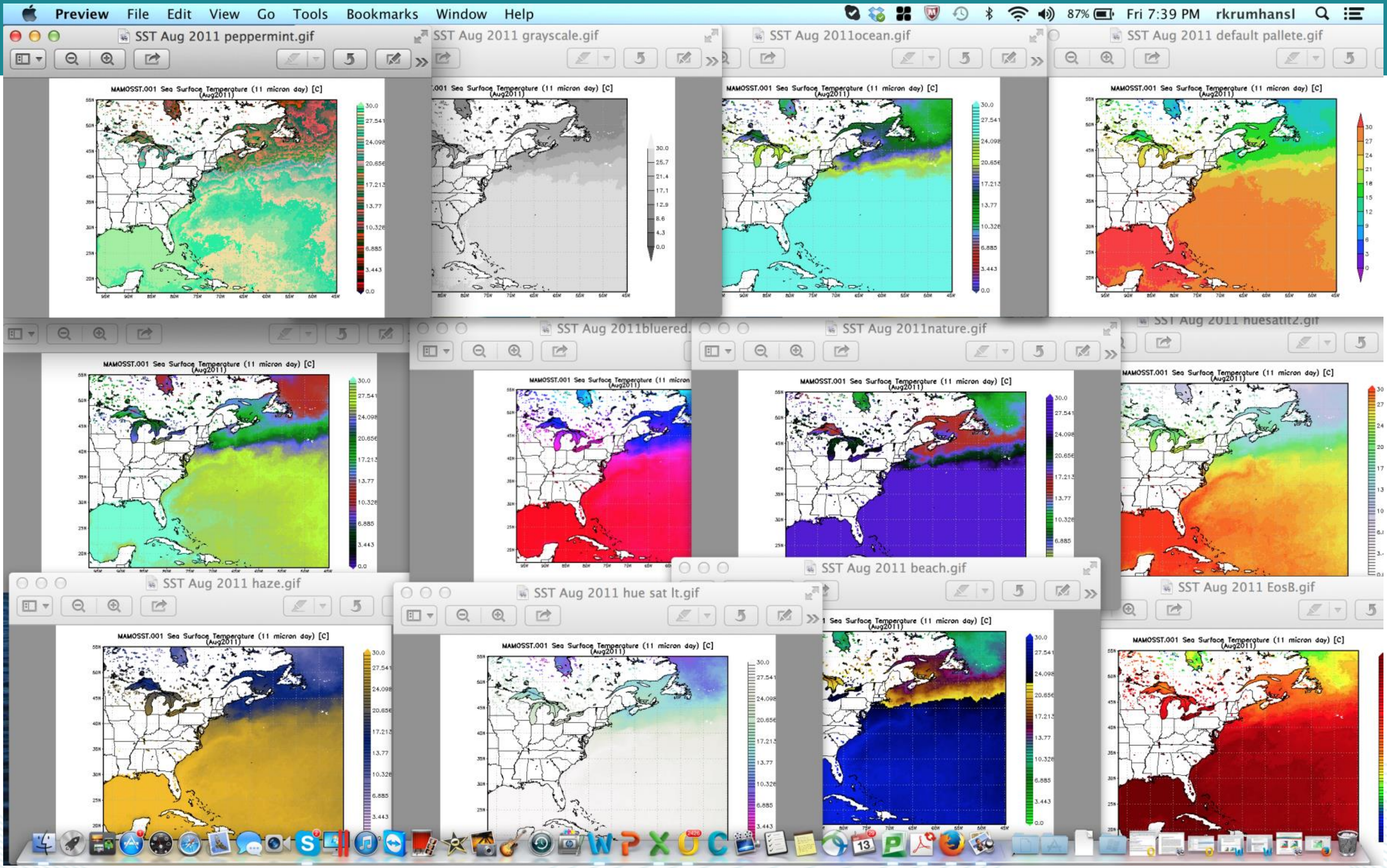

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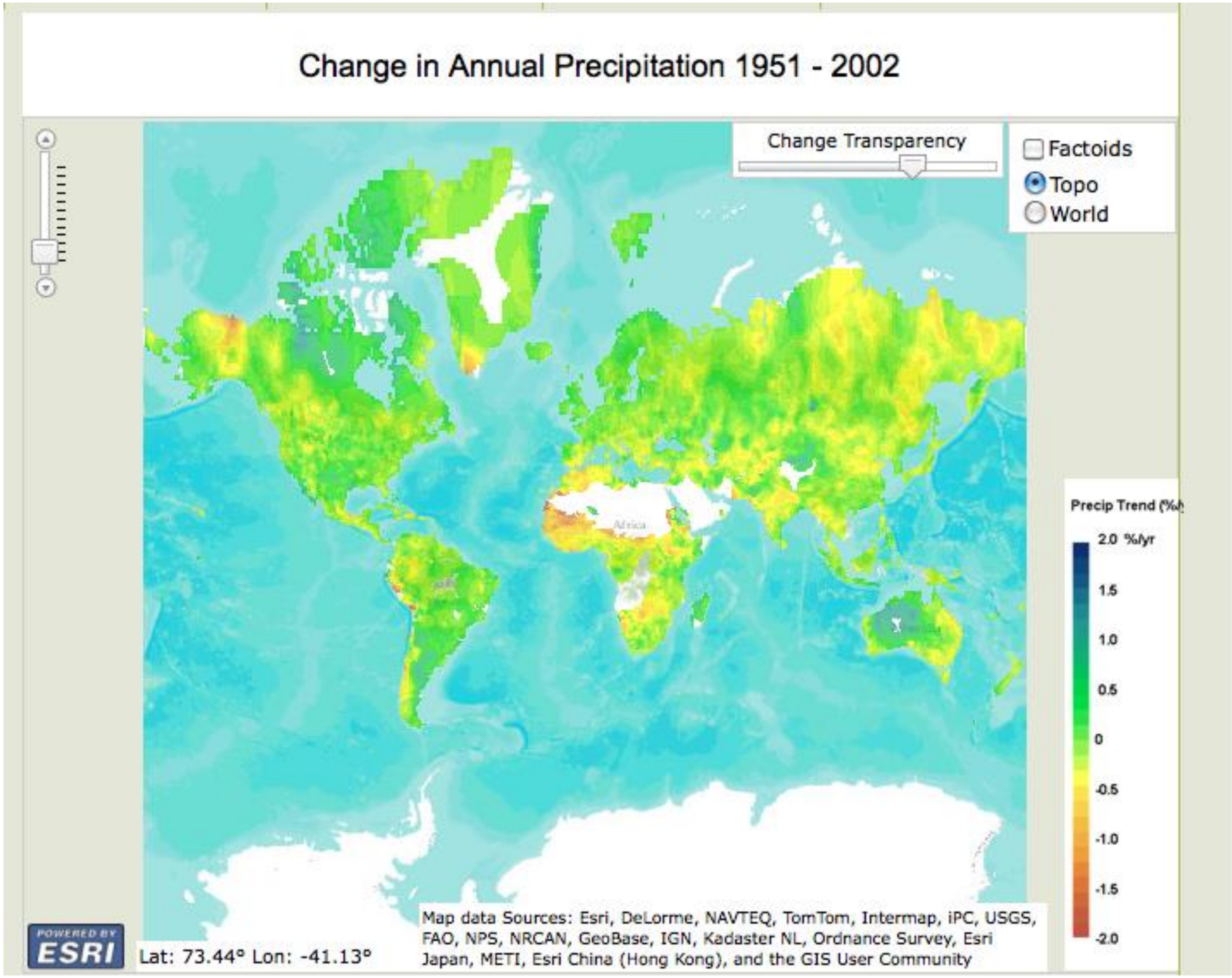
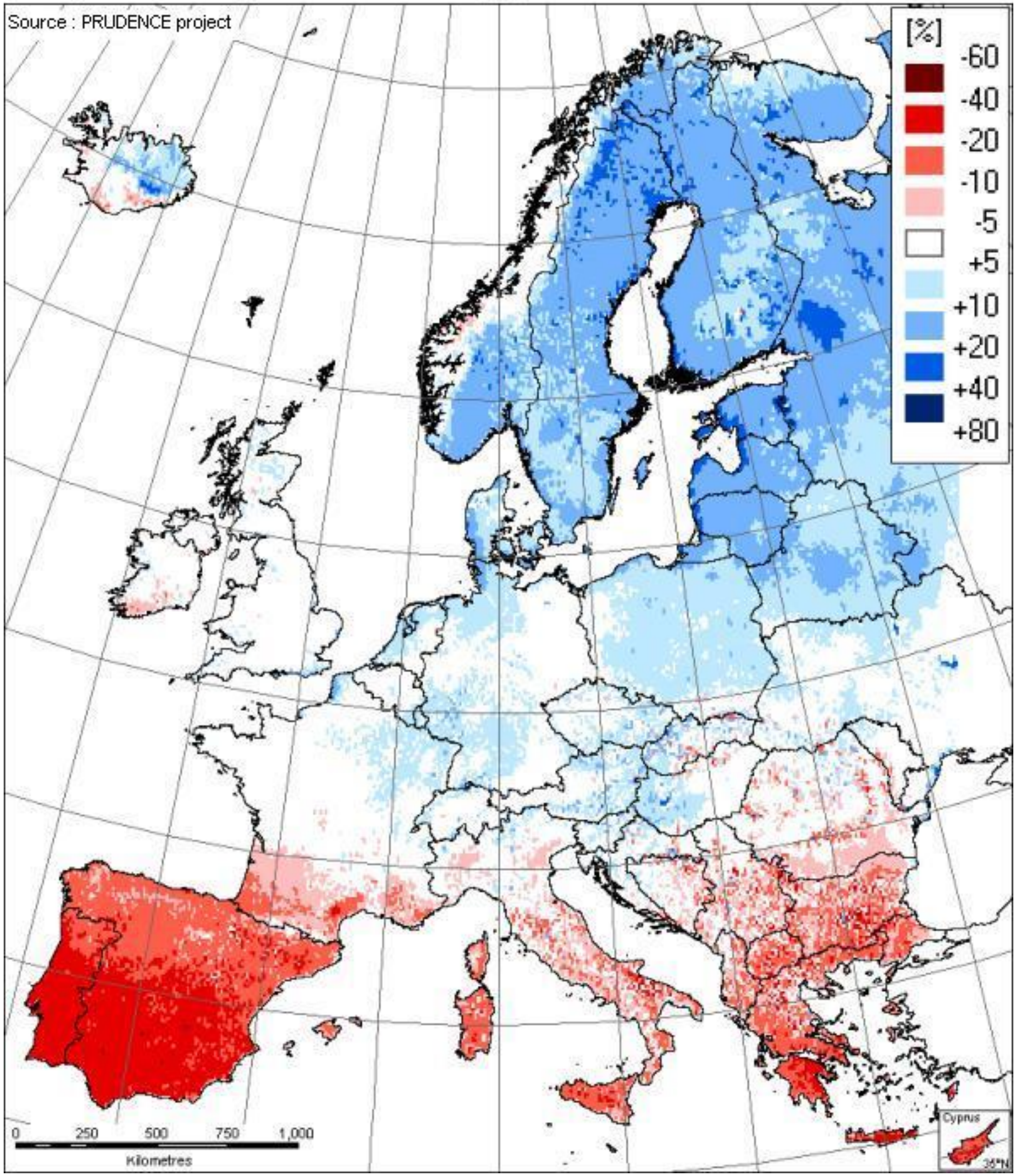
Make important information stand out



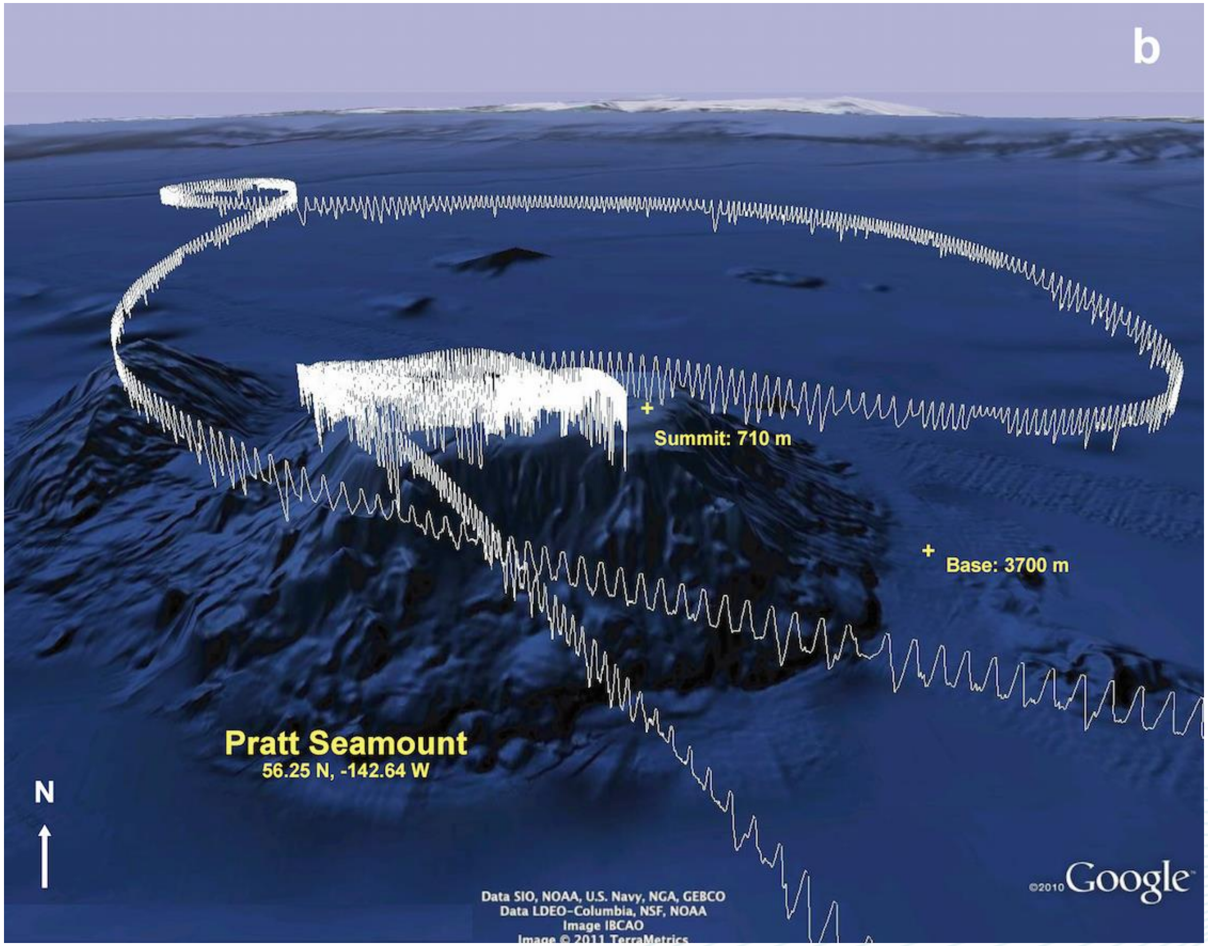
Source: generated at http://www.climatewizard.org/

Precipitation: change in annual amount [%]



Source:
http://peseta.jrc.ec.europa.eu/docs/ClimateModel.html

- Use variations in luminance to convey shape, contrast to draw attention



Data visualization created by Patrick Robinson
Citation: Maxwell, S.M., J.J. Frank, G.A. Breed, P.W. Robinson, S.E. Simmons, D. Crocker, J. Gallo-Reynoso, and D.P. Costa (2012) Benthic foraging on seamounts as a specialized foraging behavior by a deep diving marine mammal, *Marine Mammal Science* 28(3): E333-E344

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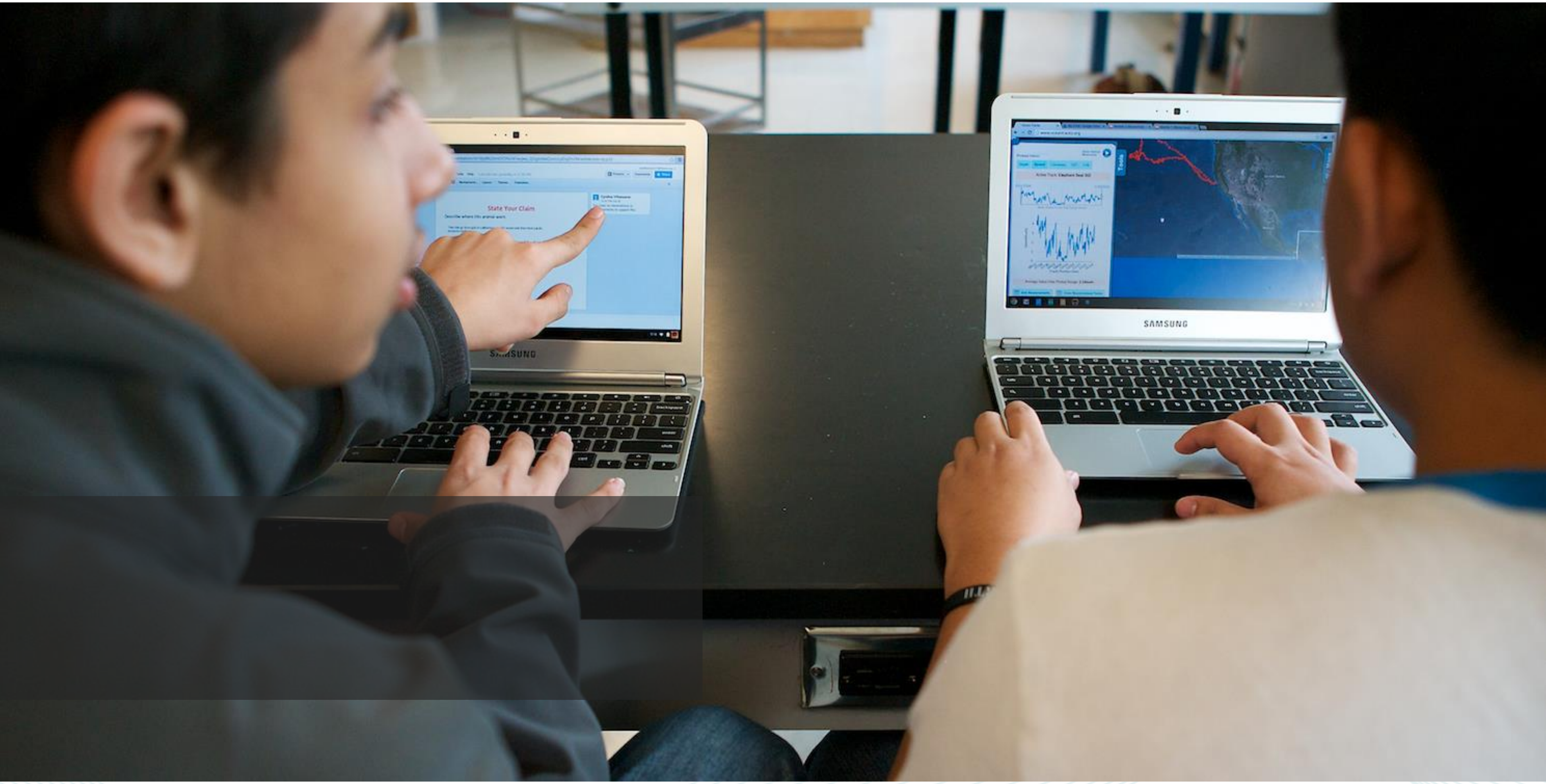
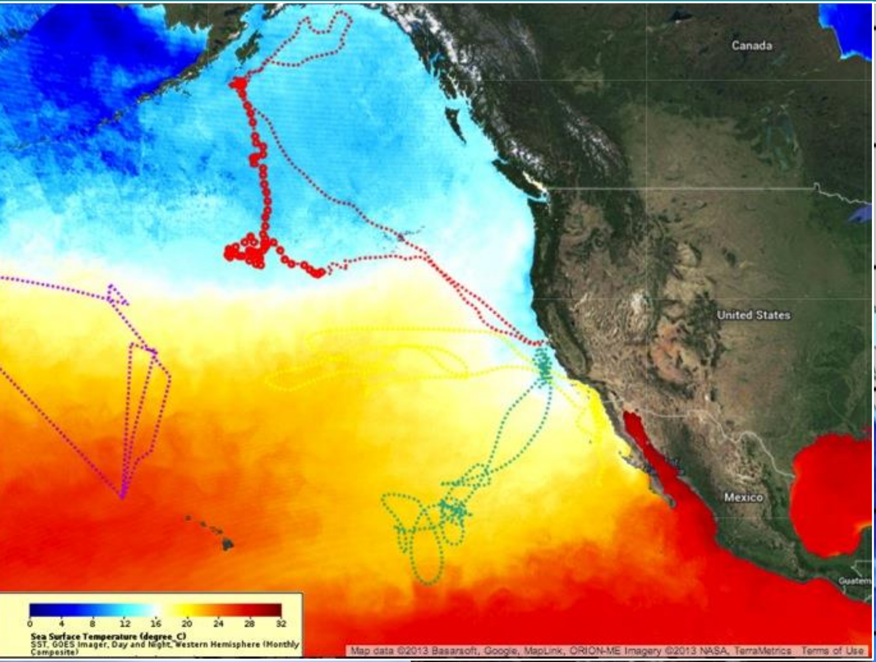
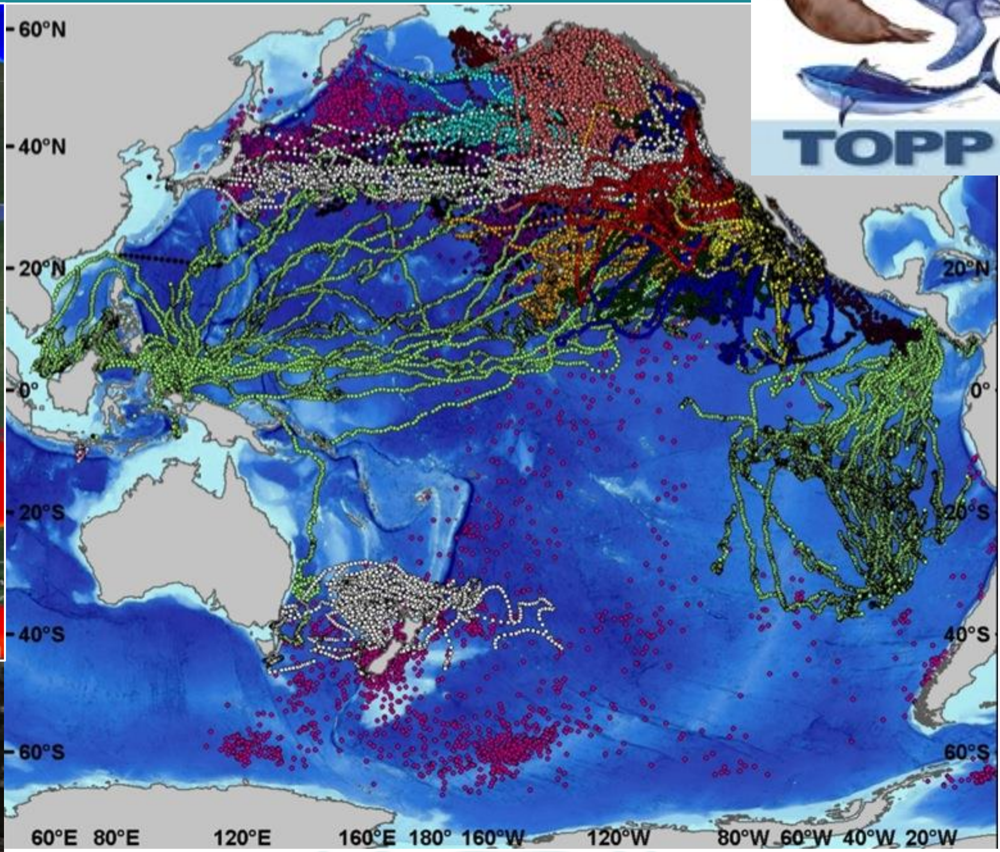
Ocean Tracks: Investigating Marine Migrations in a Changing Ocean



The Data



Canada
United States
Mexico
0 4 8 12 16 20 24 28 32
Sea Surface Temperature (degree_C)
SST, GOES Imager, Day and Night, Western Hemisphere (Monthly Composite)
Map data ©2013 Basarsoft, Google, MapLink, ORION-ME Imagery ©2013 NASA, TerraMetrics Terms of Use



60°N
40°N
20°N
0°
20°S
40°S
60°S
60°E 80°E 120°E 160°E 180° 160°W 120°W 80°W 60°W 40°W 20°W

© 2004 Jason Bradley
BradleyPhotographic.com

Our Approach

Scientific questions

Identify focused set of data and data analysis tools

Develop interface, following Oceans of Data guidelines

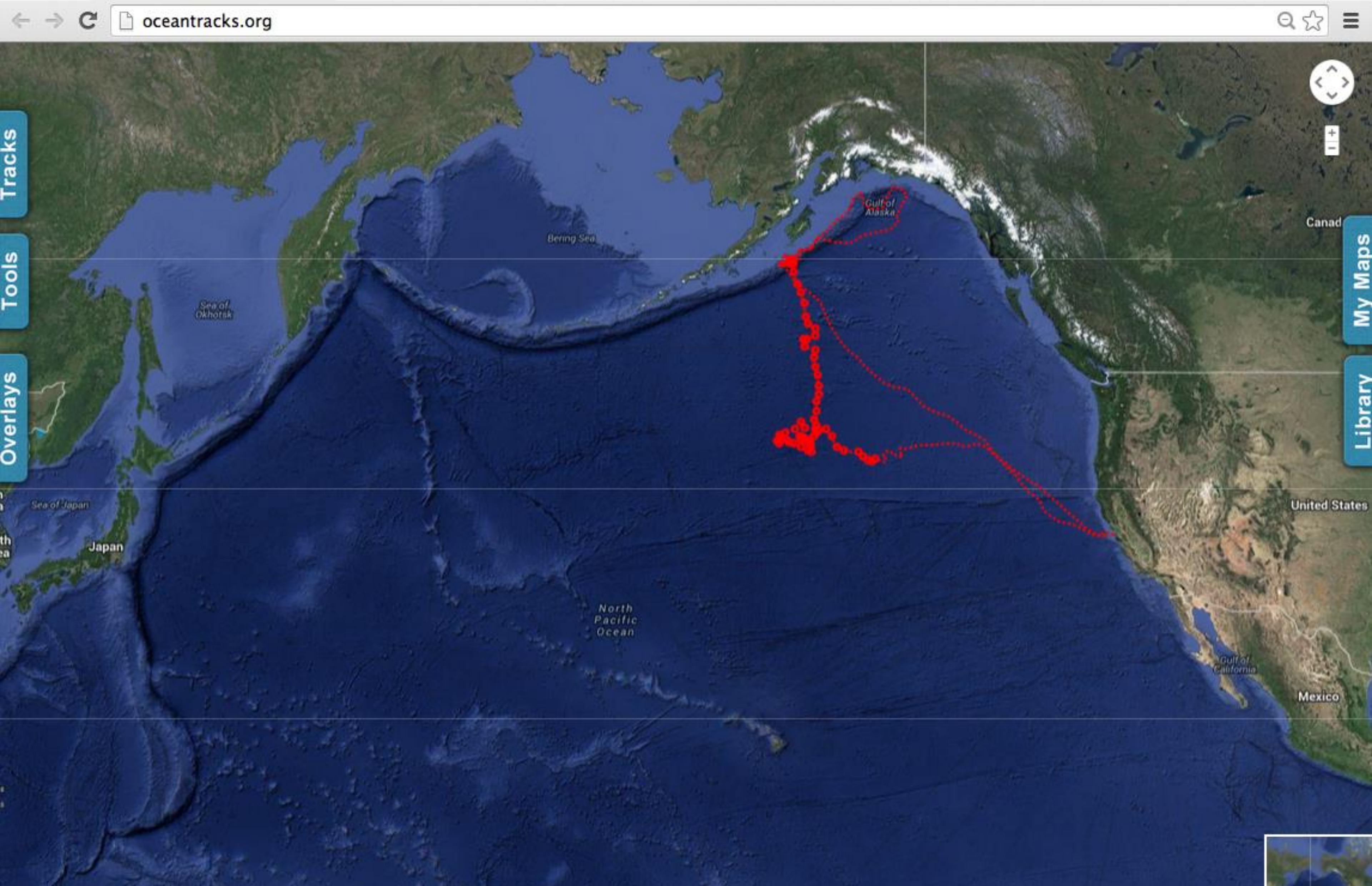
Incorporate guided student experiences and teacher supports

Goals for students

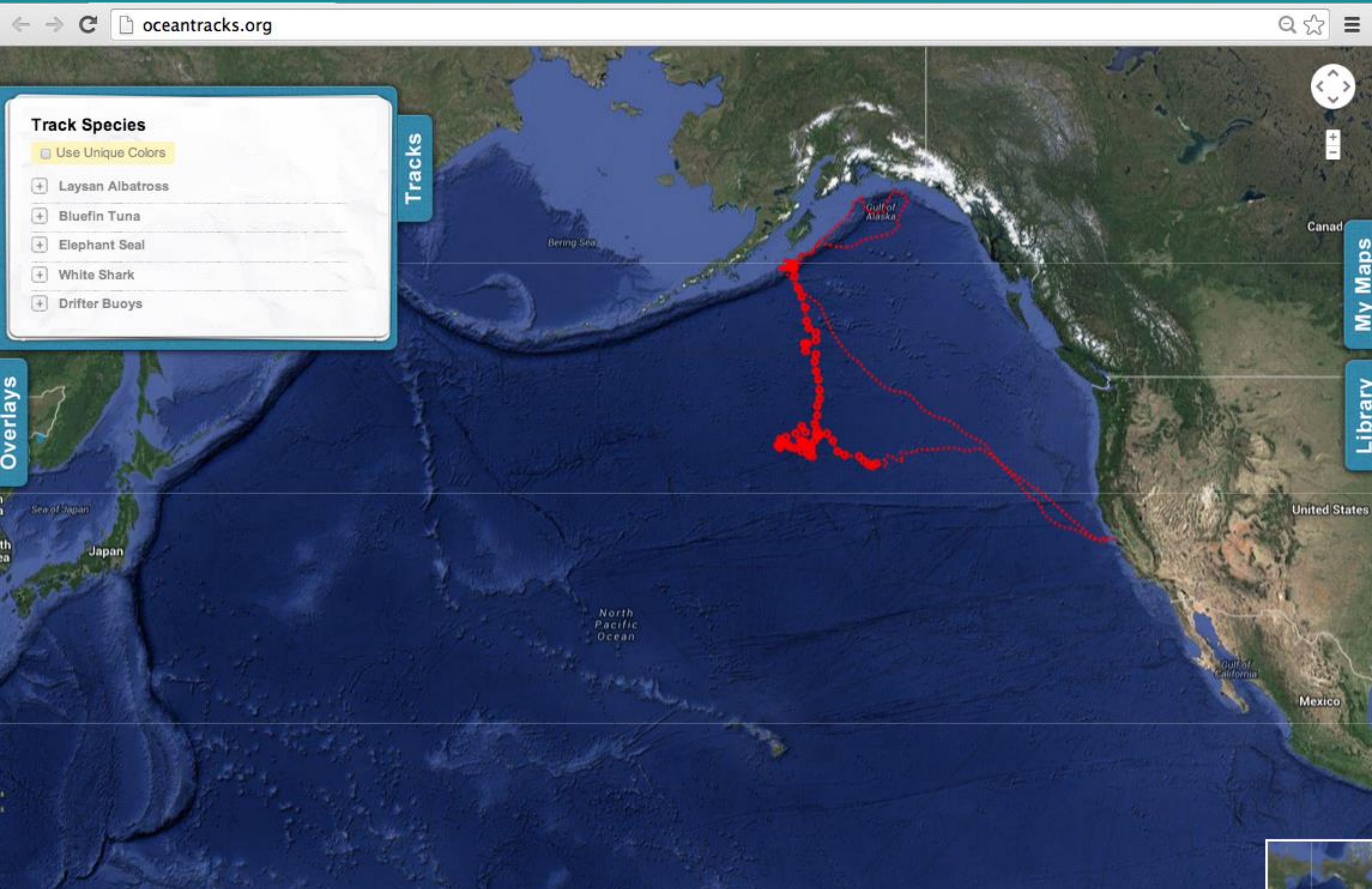
Explore questions of current scientific interest

- What might influence the movement of marine species?
- Why might movement be affected by oceanographic factors?
- How does the importance of these factors differ across species?
- Can we predict where marine species will congregate in the future, to target for protection?

The Interface



Get students quickly to the data



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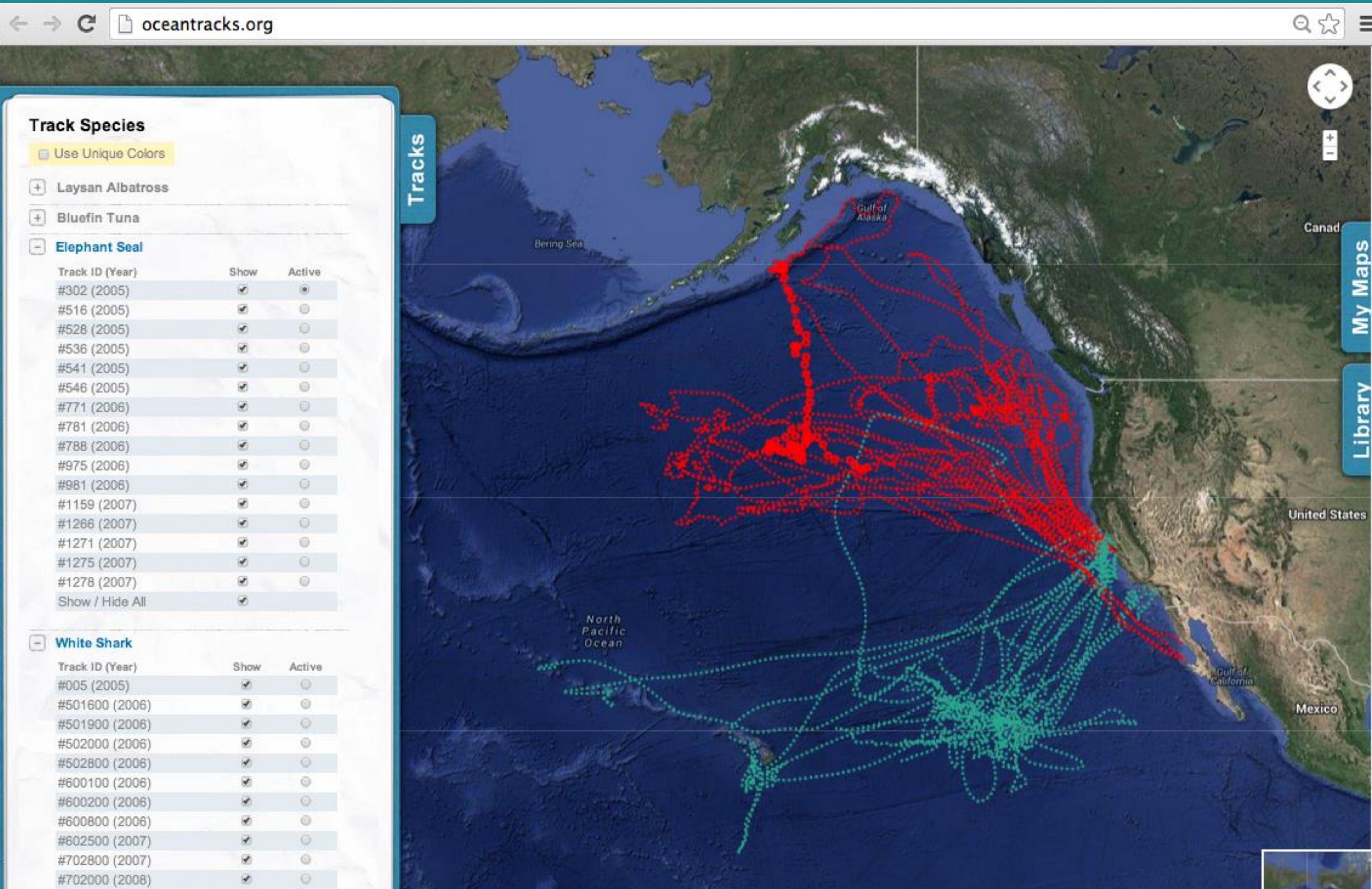
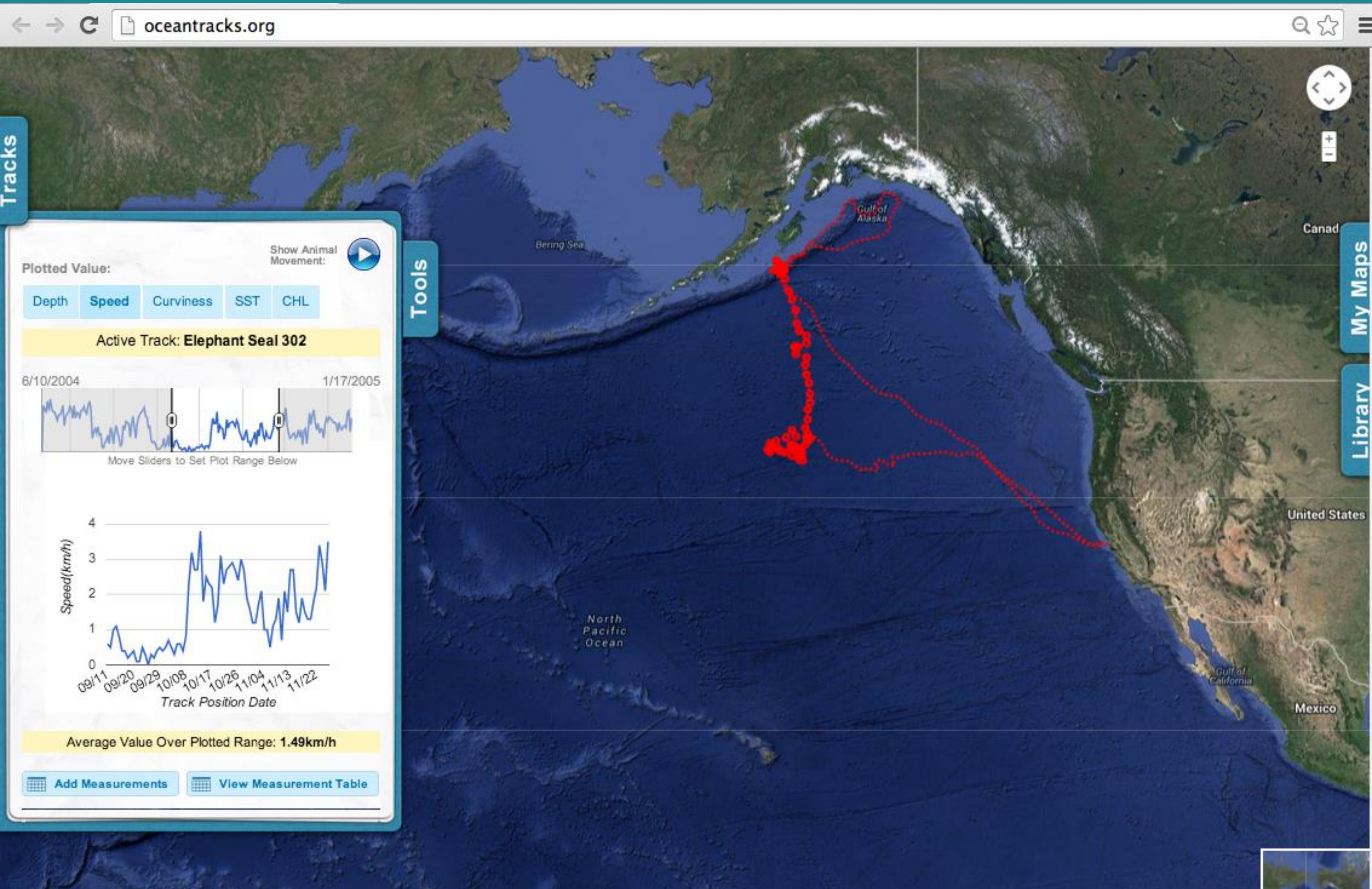


Allow them to easily create and interact with data displays



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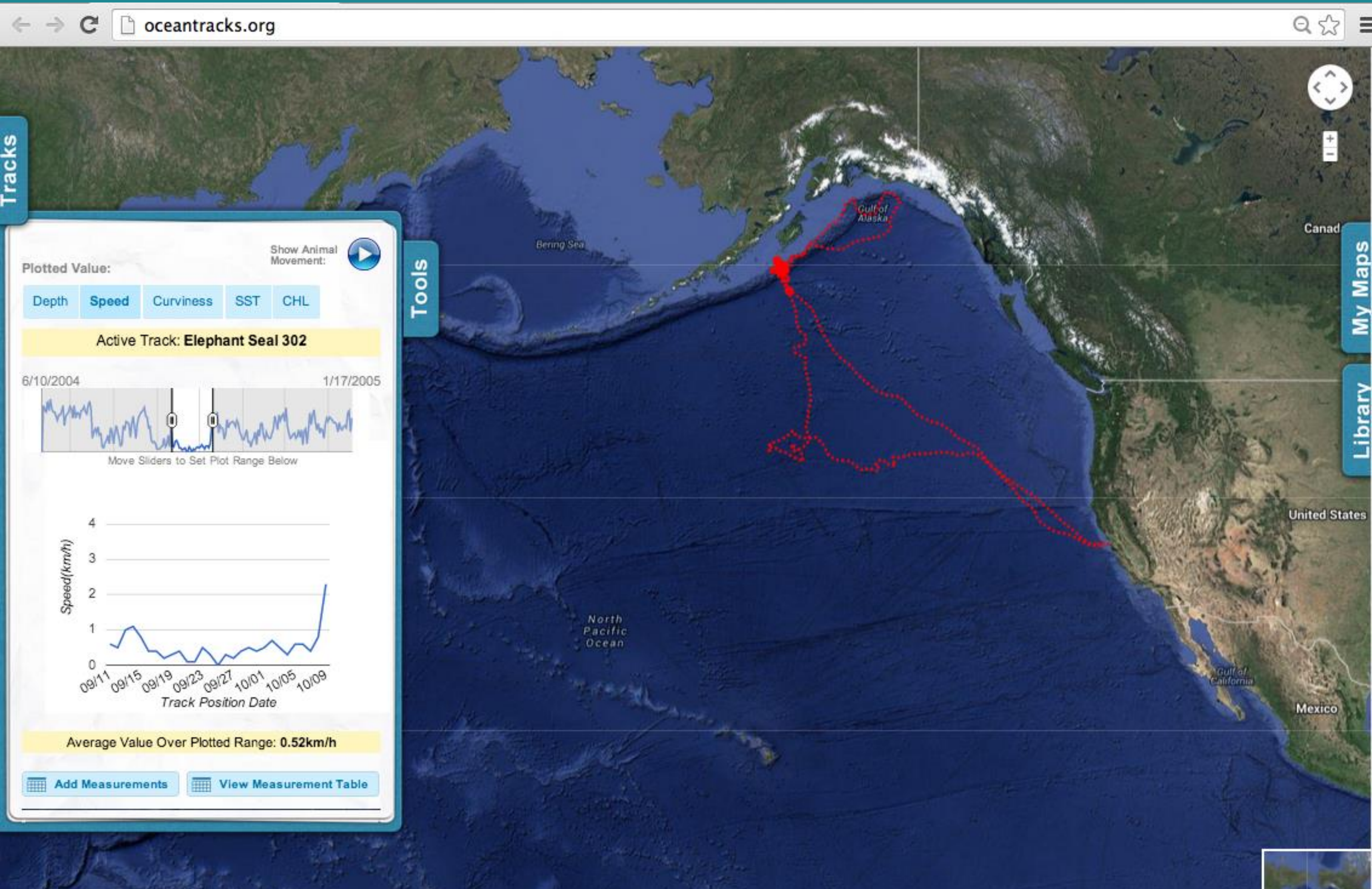

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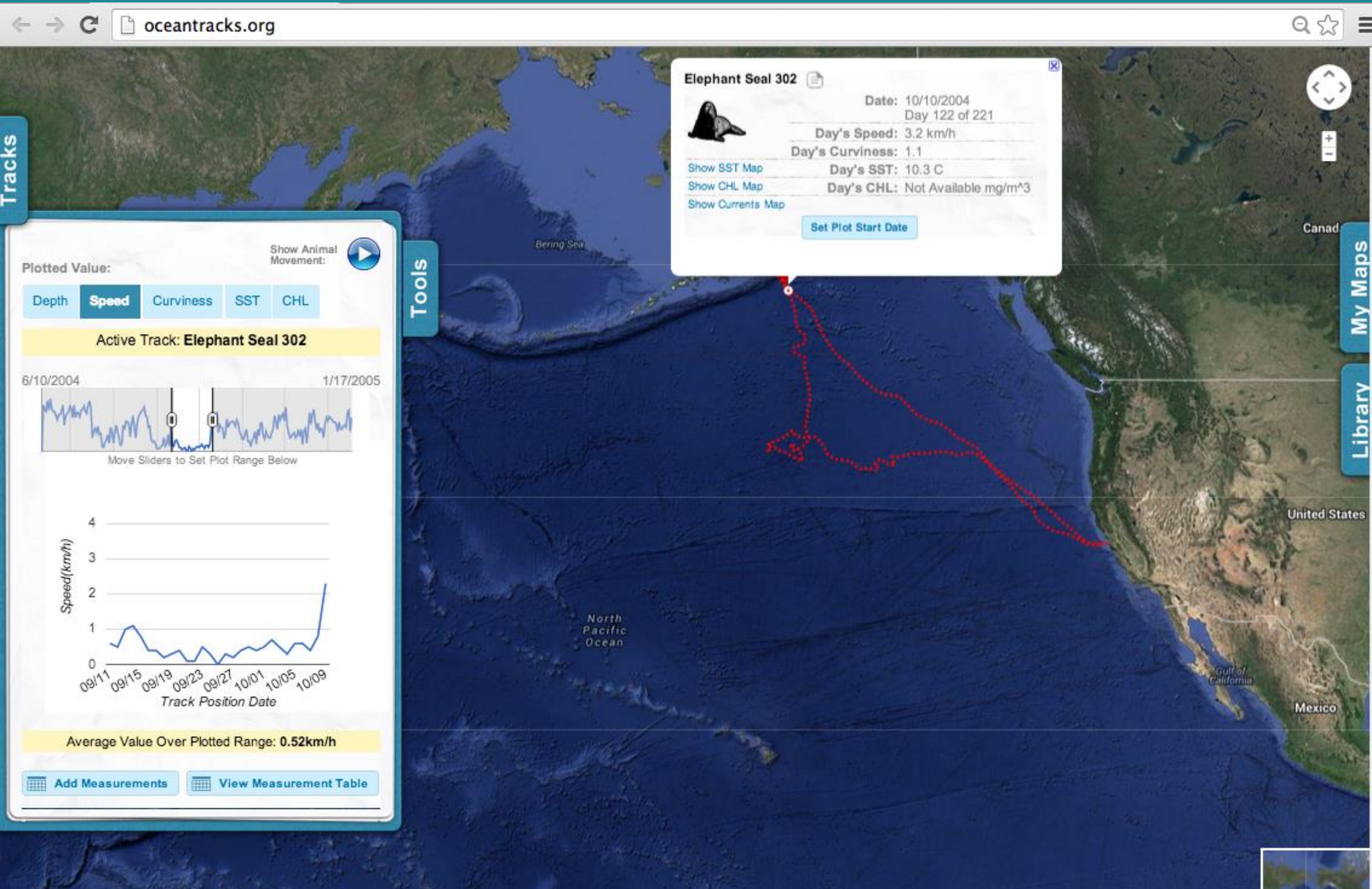
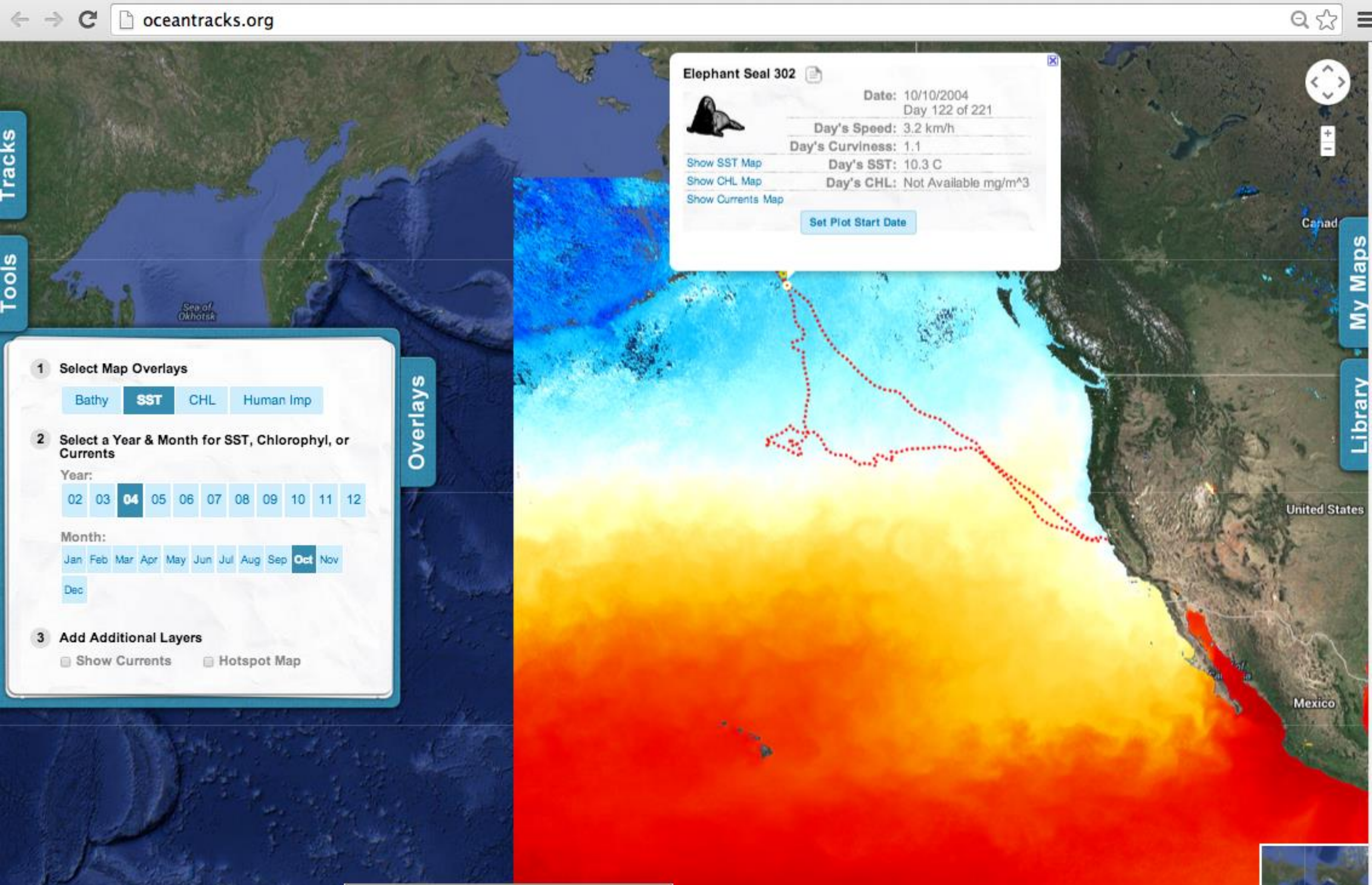
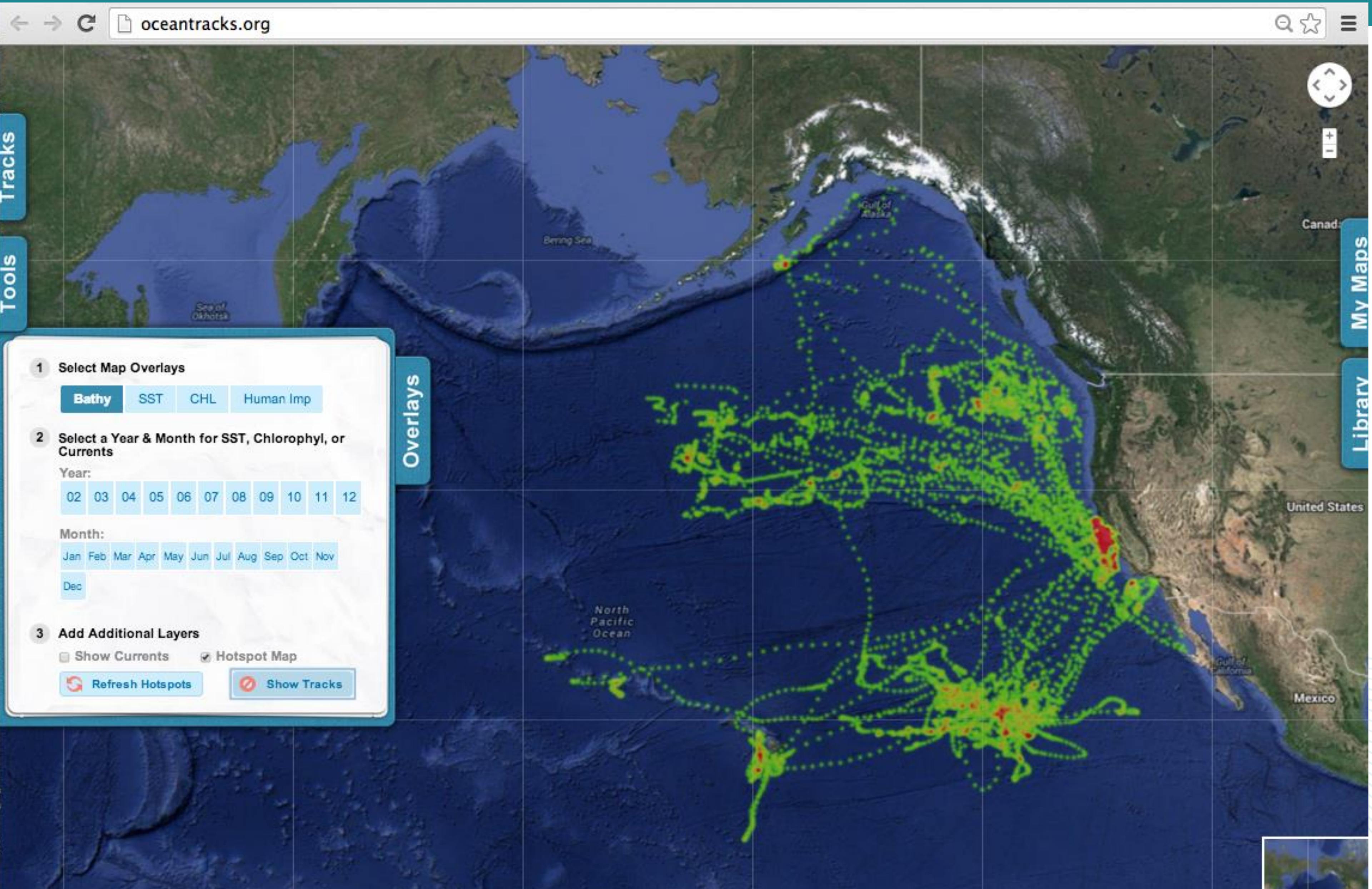


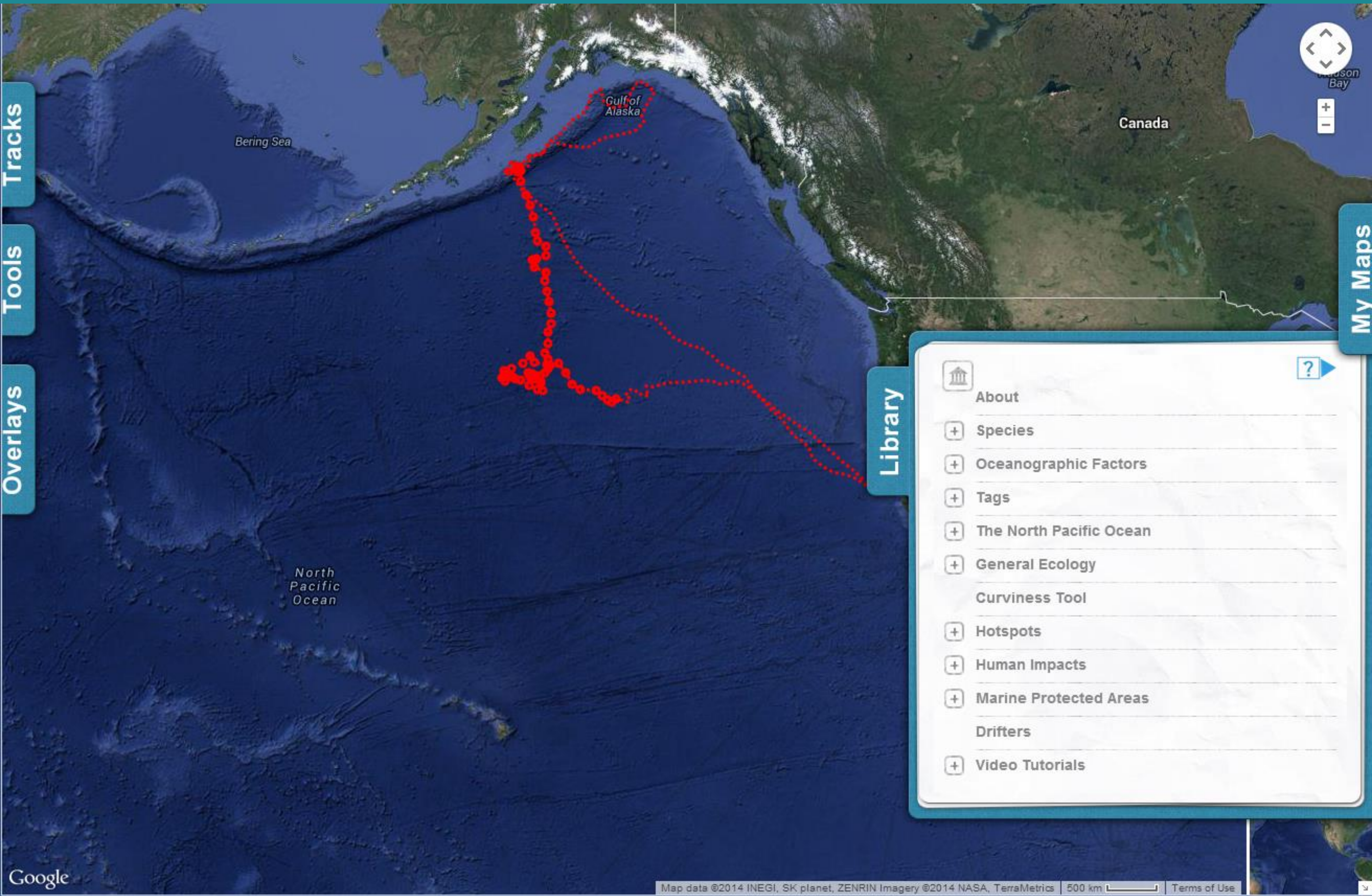
Allow them to easily create and interact with data displays



Provide tools that enable students interact with the data as scientists do



Provide supports that can be accessed on-demand



Customized content supports

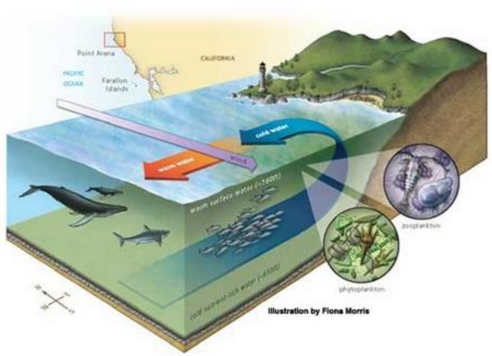
Ocean Tracks Library

Categories

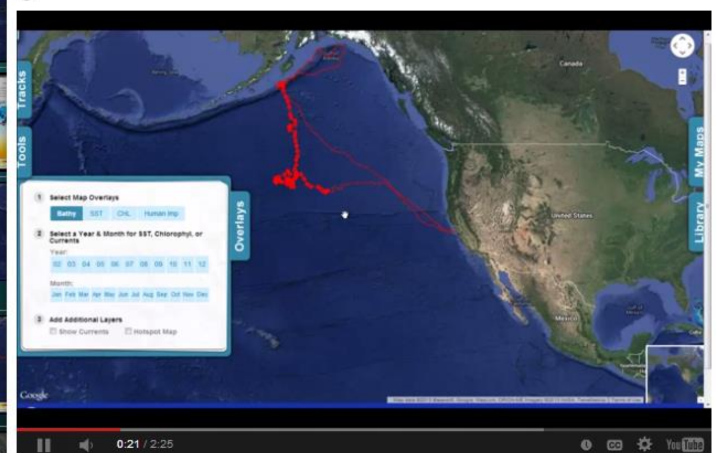
- About
- Species
- Oceanographic Factors
- Tags
- The North Pacific Ocean
  - Major Currents
  - The North Pacific Transition Zone and Transition Zone Chlorophyll Front
  - **Upwelling and the California Current**
- General Ecology
- The Curviness Tool
- Hotspots
- The Hotspot Tool
- Human Impacts
- Marine Protected Areas
- Drifters
- Video Tutorials

Upwelling and the California Current

- The California current is the **eastern boundary current** of the North Pacific Gyre, running southward from British Columbia, Canada to Baja California, Mexico. This current draws cool, nutrient rich waters from the Alaska current down along the western coast of North America.
- Western boundary currents flow deeper and stronger than eastern boundary currents. This means that cool, nutrient-rich water is closer to the surface in eastern boundary currents than western boundary currents. This results in the creation of **rich upwelling zones** in areas with eastern boundary currents, such as the California Current.
- The intensity of the California current is influenced by strong northwesterly winds. These winds predominantly blow along shore, which because of the earth's rotation (see Eckman transport) cause water to be transported in an offshore direction. This movement of water offshore causes cooler, nutrient rich water to be upwelled over the narrow continental shelf to the surface.



1. To access the map, click here.
2. The map works like other Google maps interfaces, with zoom and pan functions on the upper right hand side of the screen. You can also click and drag the map to get to a different location.
3. A small map on the bottom right hand side of the screen shows you a zoomed out view to help you orient yourself.
4. The map interface has a set of menus that expand from tabs on the left and right hand sides of the screen. Click the tab to expand the menu.
5. The track you see on the map was made by an Elephant Seal (#302). Watch the tutorial videos below to learn how to interact with this track and others.



working.

The Library - This video shows you how to access and use the Library, where you'll find more information about the animals and the ocean, as well as the technologies used to explore them.

Overview - This video is a compilation of all the videos above. It takes you through all the elements of the Ocean Tracks map interface, just as they are listed here.

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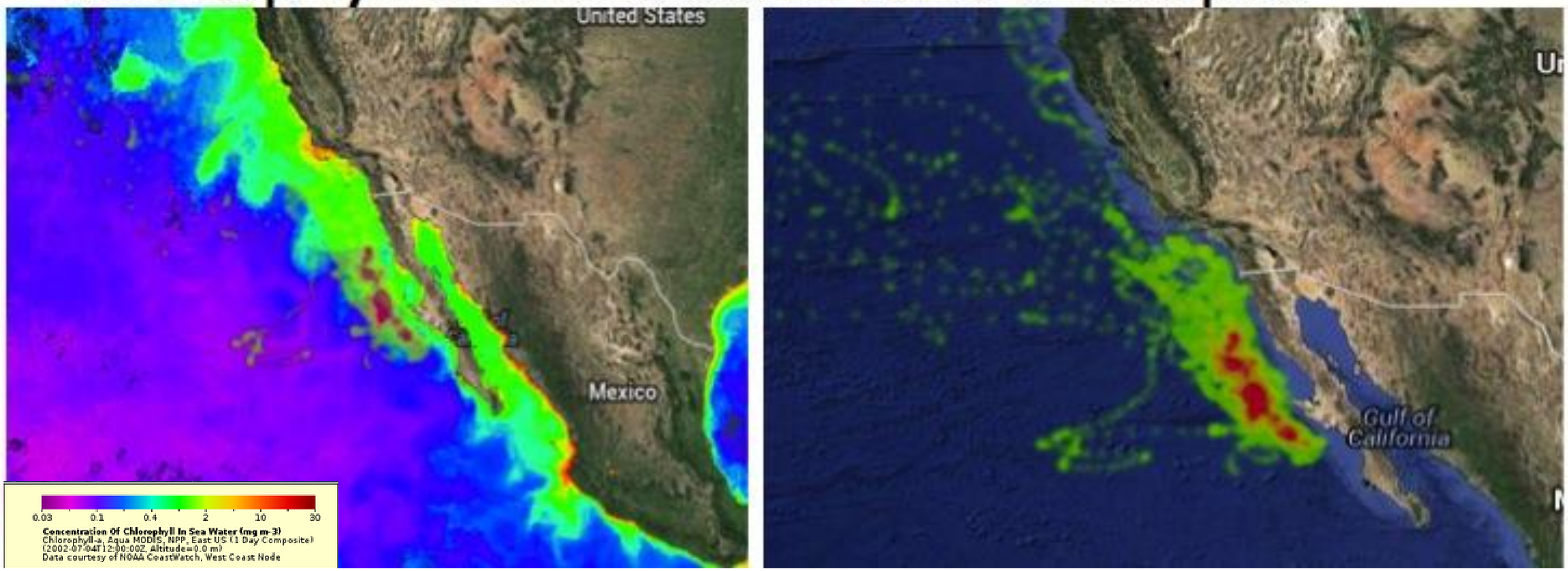
Where are the biodiversity hotspots in the Pacific Ocean?

Chlorophyll in the bluefin tuna's hotspot



"The chlorophyll levels in this area where the hotspot is are very high. Which makes it a very attractive spot for these animals. This hotspot is pretty much right on and right next to the continental shelf which is a place in the ocean where large amounts of upwelling occur. Also the temperature by the coast is leaning towards the colder side. It stays around 12-16 degrees celsius. Which means since it's colder water there is more upwelling. " – Student Work

Ocean Tracks: College Edition

- Step 1: Needs Assessment
  - Student interviews
  - Faculty surveys
  - Textbook/syllabi reviews

- Step 2: Curriculum Development

- Step 3: Classroom testing and evaluation
  - Palomar College – non science major, online
  - Scripps Institution of Oceanography – science majors, classroom setting

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Ocean Tracks: College Edition

Research questions:

1. How do current oceanography and marine biology faculty use large-scale datasets in their courses?

2. What supports may be needed to incorporate *Ocean Tracks* into undergraduate science courses?

3. How do undergraduates engage in and interact with online vs. face-to-face versions of OT-CE?

4. Does OT-CE improve undergraduate students'
   - engagement in scientific practices & interest in scientific careers?
   - knowledge of core content & competence in scientific practices?

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Thank you! Questions?

For more information, contact:

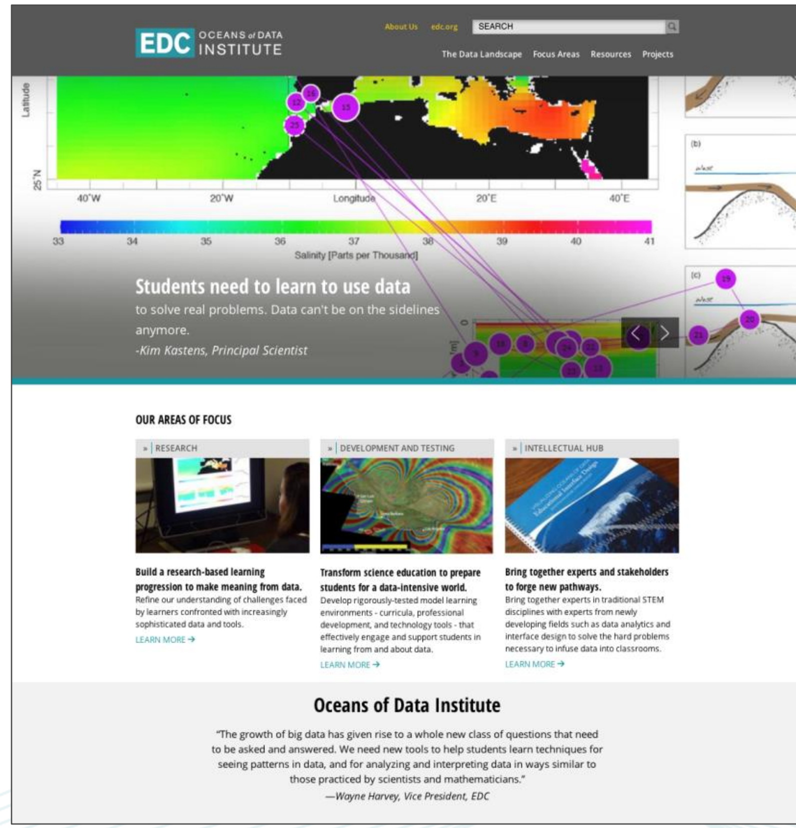
Ruth Krumhansl, Director

Oceans of Data Institute

oceansofdata@edc.org

And visit our website –

http://www.oceansofdata.org



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