

What are our motivations for teaching with data?

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Oceans of Data Institute, EDC

Presented at: Ocean Observatories Initiative (OOI) Teaching with Data Workshop
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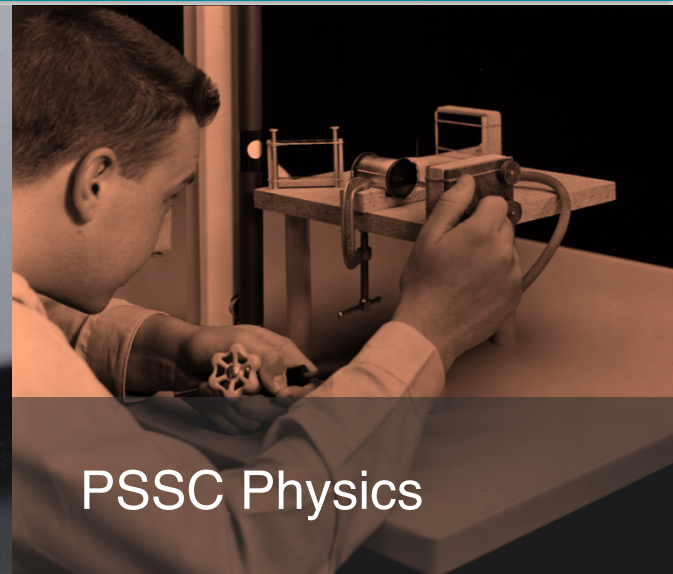


About EDC



A global nonprofit organization that develops innovative programs to solve some of the world's most urgent challenges in education, health, and economic development

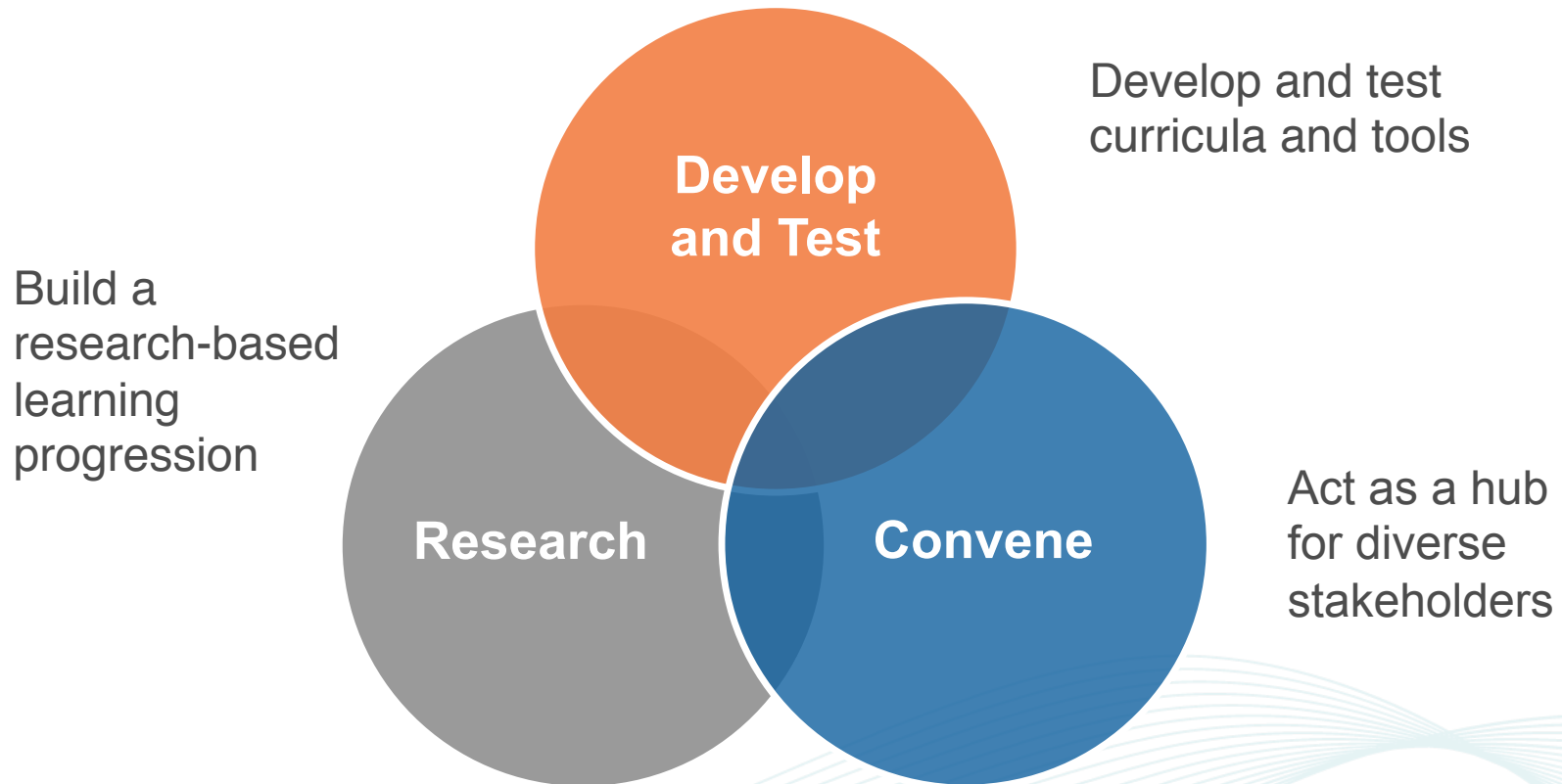
EDC's history in STEM education



PSSC Physics



Oceans of Data Institute: Promoting the data literacy of K-16 students



Why teach with data?

1. We live in a data-intensive world.
2. The job market demands it.
3. Data literacy is an integral part of learning science.
4. Because we can.



1. We live in a data-intensive world.



2.5

QUINTILLION

bytes of data are created daily

Source: "The Big Picture on Big Data," GovCon Exec, Spring 2012.

2. The job market demands it.

**THE WALL
STREET
JOURNAL.**

Get Familiar With Big Data Now—or Face 'Permanent Pink Slip'

Demand Rises for Analytics Professionals, Data Scientists (2014)

“Basic skills in working with data that every person should have are not being taught in K-16 schools. Thus, they are lacking at the highest levels in the broad array of professions that are becoming increasingly data-driven.”

Juan LaVista, Principal Data Scientist at Microsoft

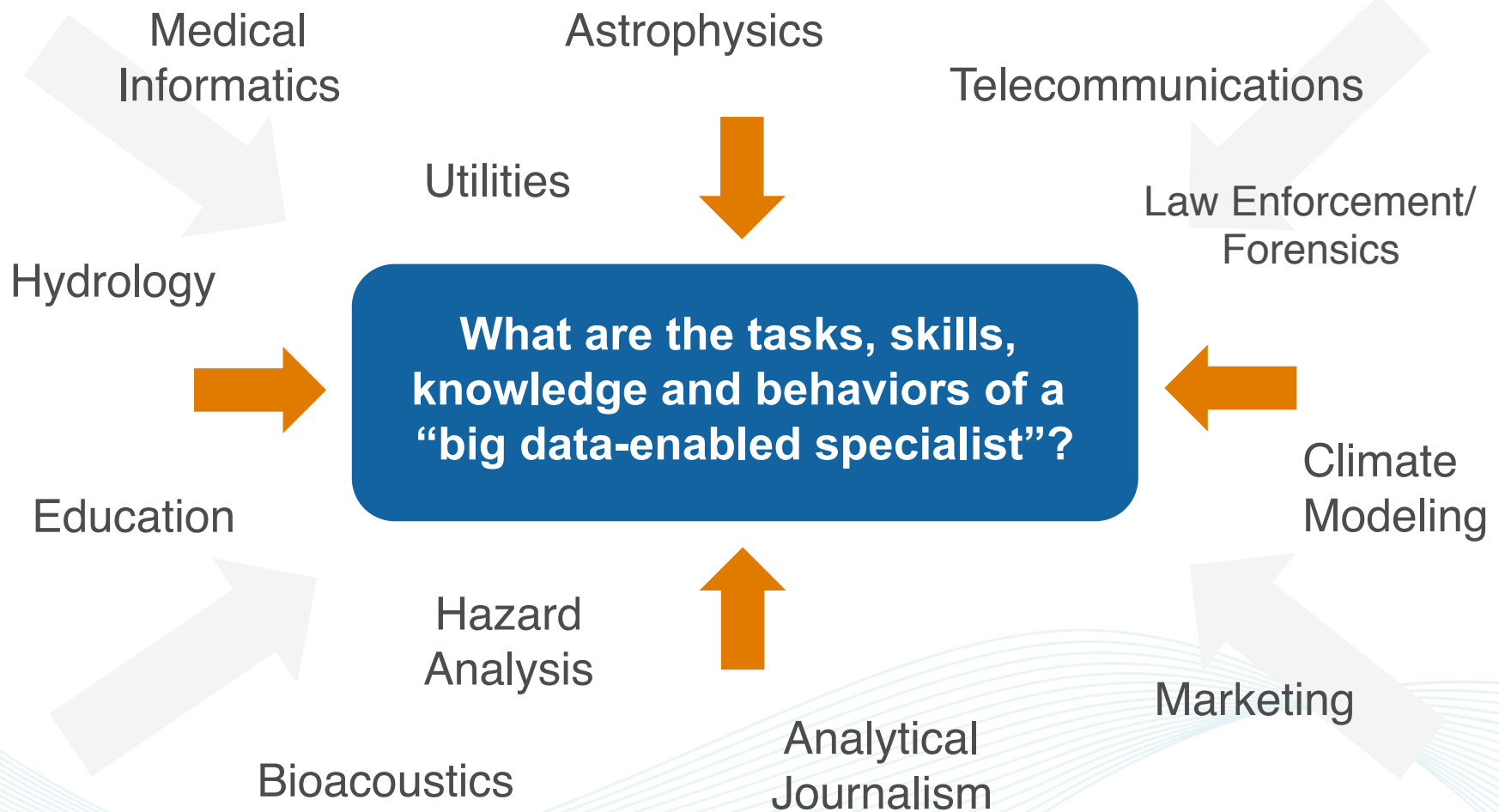
“By 2018, the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions.” (McKinsey Global Institute, 2011)

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.**

Developing an Occupational Profile



What are the knowledge, skills, 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:

Knowledge:

- Analytic Thinking (89%)
- Algorithms (76%)
- Data Modeling (70%)
- Data Structures (70%)
- Best Practices (69%)
- Statistics (69%)

Skills:

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

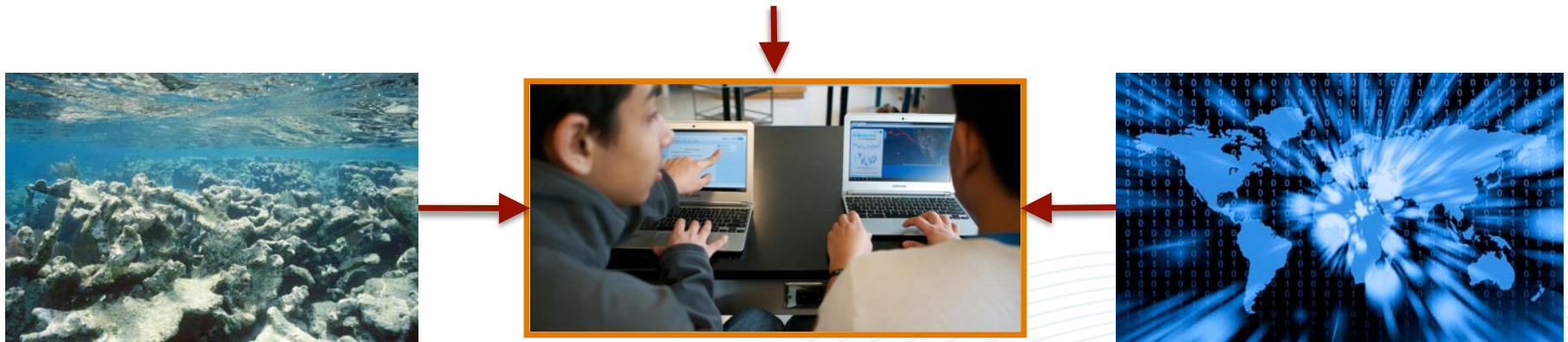
Behaviors:

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

3. Data literacy is an integral part of learning science

“Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. Both elements—knowledge and practice—are essential.”

Next Generation Framework for K-12 Science Education, NRC 2011, p. 2-3



Using data helps develop key problem-solving skills and increase relevancy of science content.

Use of authentic scientific data in classrooms enables students to engage in learning activities that are more deeply inquiry-based and enable higher development of problem-solving skills, address more complex concepts, and offer greater relevance to students' lives than traditional learning activities.

(Hotaling, 2005; Parsons, 2006, Simmons, Wu, Knight, & Lopez, 2008)

Using data will help students gain a deeper understanding of content.

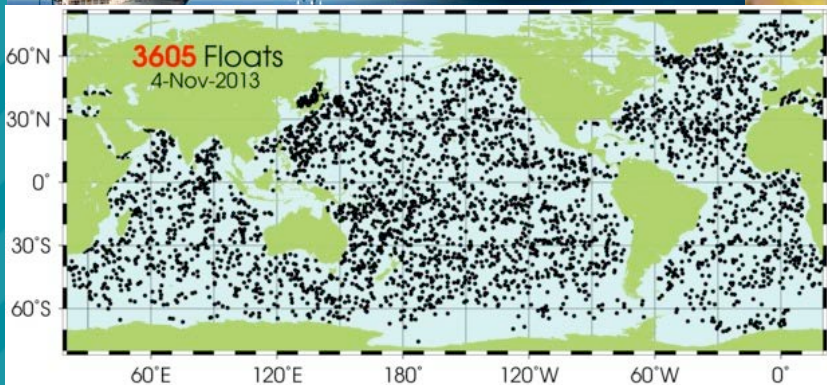
There is now considerable evidence that knowledge acquired by students via simply “taking in” or memorizing information is fragile and can be superficial. To build a more robust and enduring understanding of content, students in science classrooms need to actively engage with new information, connecting and applying concepts as they construct scientific explanations for observed phenomena.

(NRC, 2000, 2012)

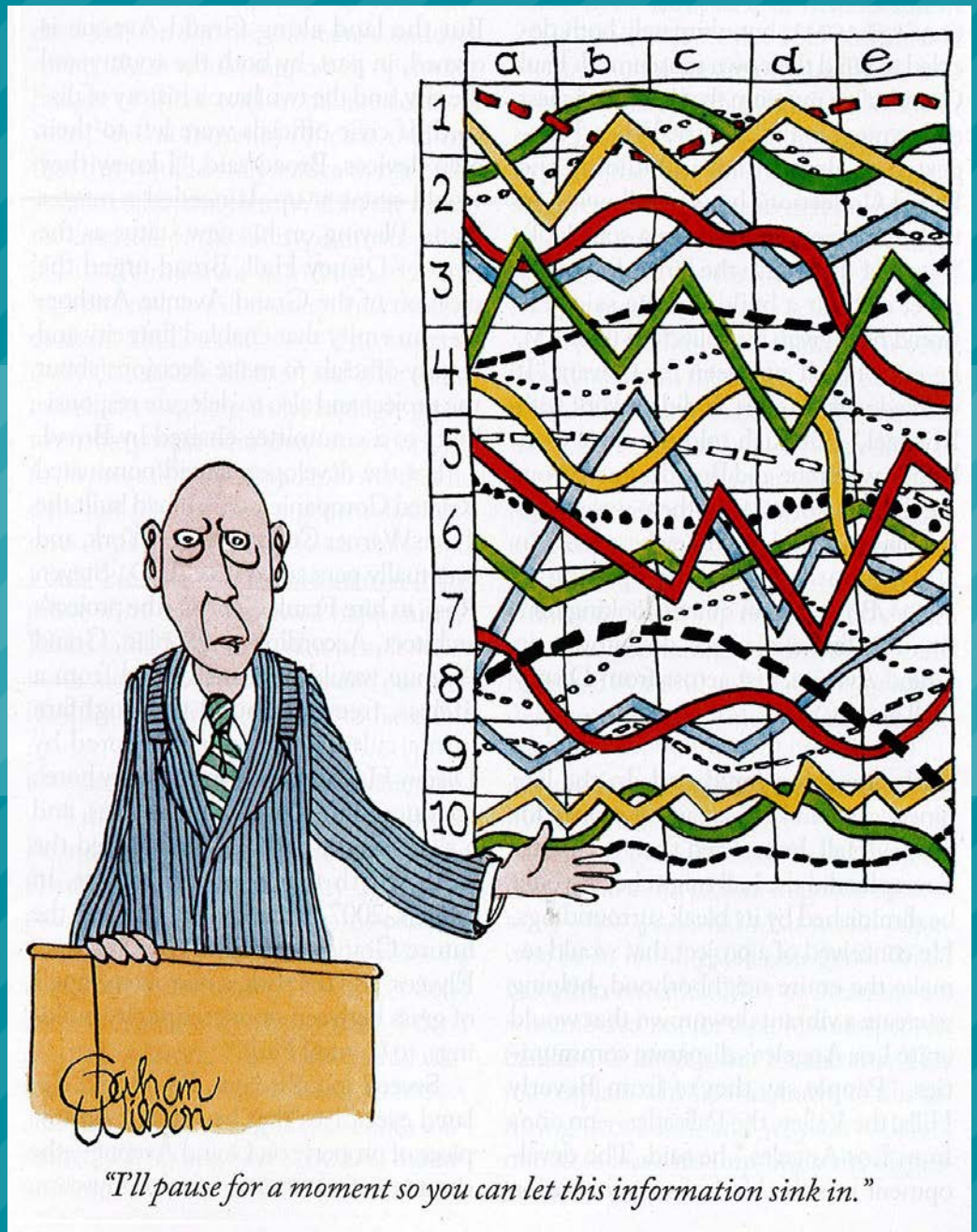
4. Because we can.

CYBER-
INFRASTRUCTURE

The amount of data available to us
(and our students) is unprecedented.



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



What are some of those 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.

What's different about “big” data sets?

Complex – include different types of data, collected different ways

Large – there are more data than you need to answer any particular question

Interactive – you are able to explore the data interactively, comparing different sets of data via a variety of data visualizations

Professionally-collected – it was collected by “others” (not the student)

Challenging transitions

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

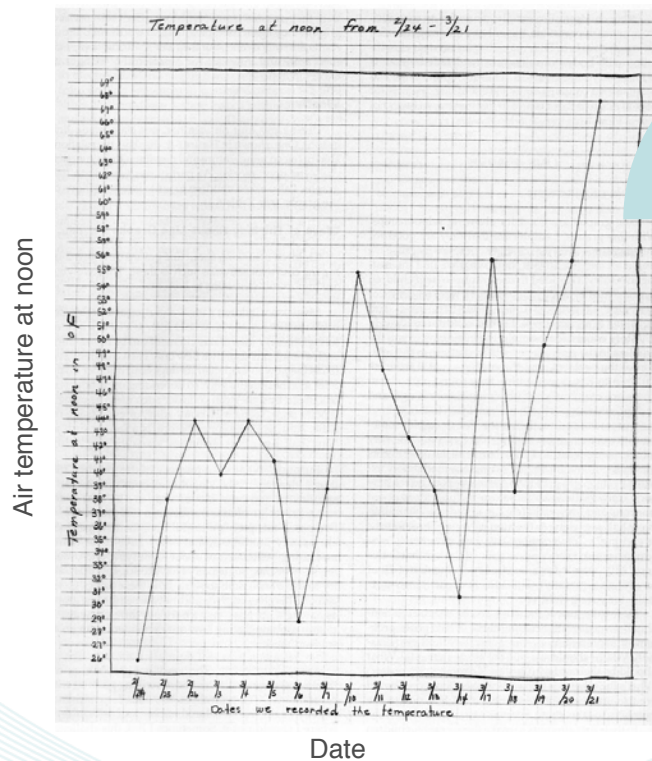
Metadata



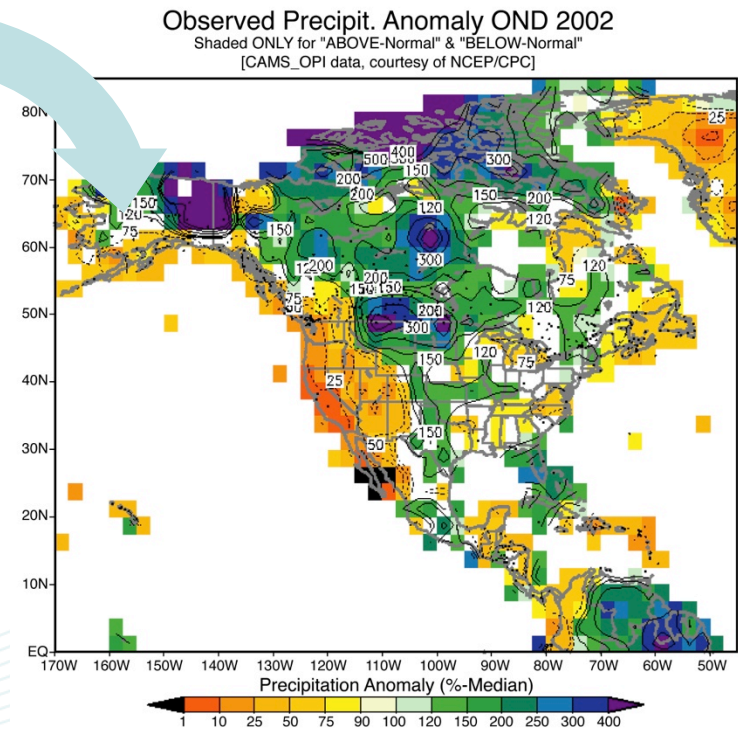
Photo credits: (left) School in the Forest powerpoint, <http://www.blackrockforest.org/docs/about-the-forest/schoolintheforest> (right) Using a Digital Library to Enhance Earth Science Education, Rajul Pandya, Holly Devaul, and Mary Marlino)

Challenging transitions

Dozens of data points

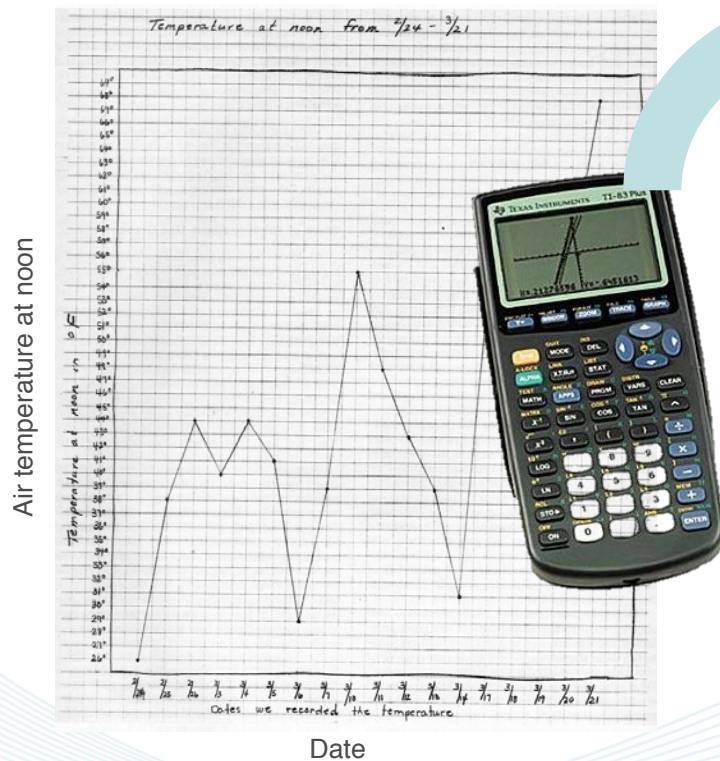


Petabytes

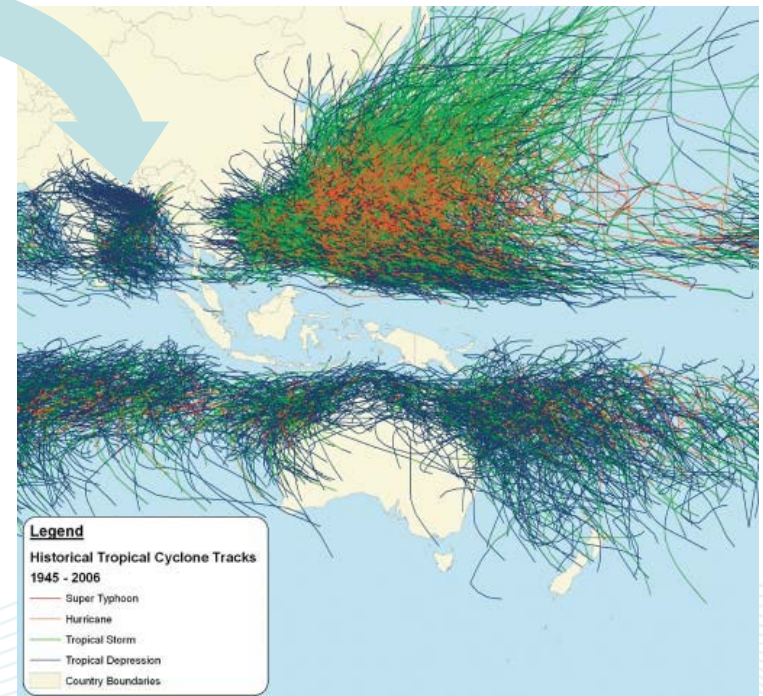


Challenging transitions

Simple, transparent tools and techniques



Sophisticated tools and techniques



Other challenges

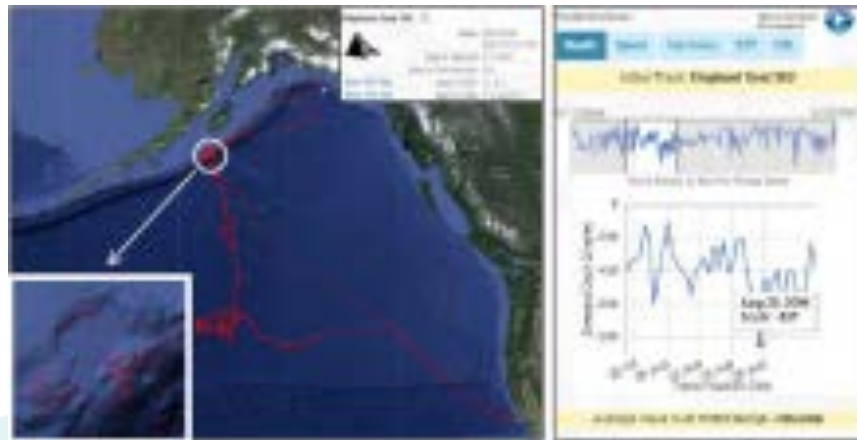
- Expert data access and data representations may be baffling to students.
- Working with real data can be messy and without clear answers.



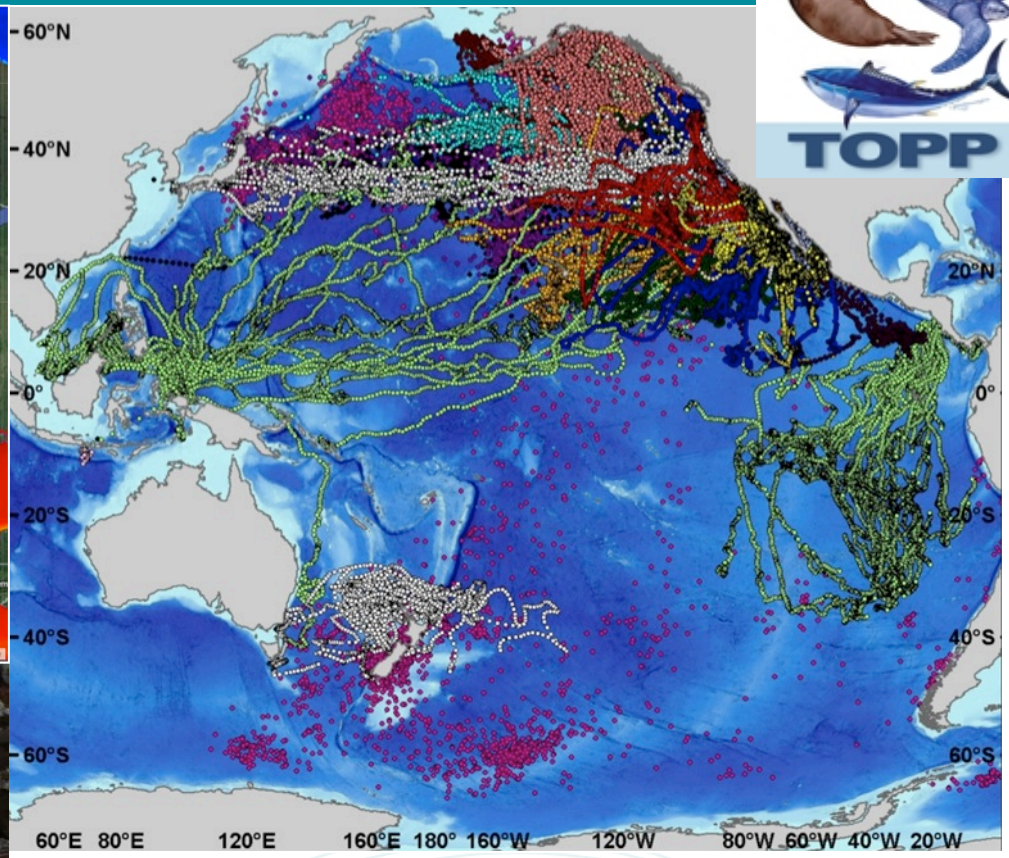
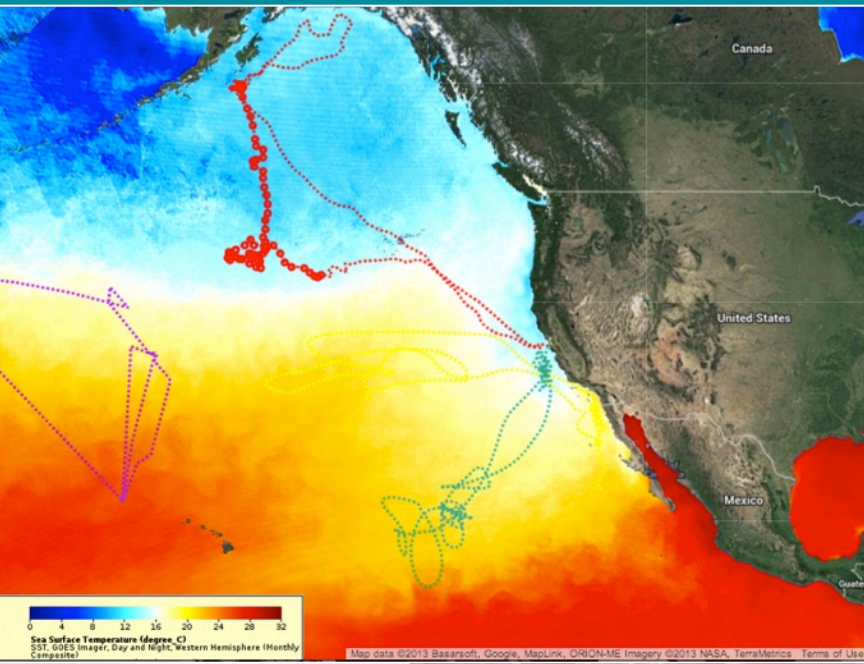
How ODI Approaches Teaching with Data

OCEAN TRACKS—COLLEGE EDITION

The project is creating an interactive Web-based learning resource to help students at different types of undergraduate institutions develop valuable skills in analyzing and learning from large, authentic scientific datasets. This project is investigating how a learning resource that includes a data interface, set of analysis tools, and curricula can be used to motivate diverse populations of college students to learn and do science with real data, bringing opportunities to engage broad student populations in scientific practice.



The Data



OT-CE Curriculum Modules



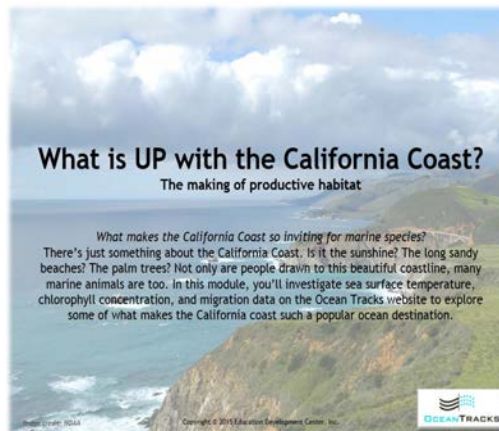
Tag – You're It!

Exploring Ocean Tracks Data

How do you gather and display data about the travels and behaviors of real, live marine animals? Electronic tagging technology lets us track marine animals' migration, feeding, and breeding patterns, as well as information about the variety of environmental conditions they experience as they traverse the oceans. Dive in! Hit the beach in Hawaii with a white shark. Play "tag" with an elephant seal. Learn how marine animals are tagged and tracked across the Pacific.

North Pacific Ocean

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What is UP with the California Coast?

The making of productive habitat

What makes the California Coast so inviting for marine species? There's just something about the California Coast. Is it the sunshine? The long sandy beaches? The palm trees? Not only are people drawn to this beautiful coastline, many marine animals are too. In this module, you'll investigate sea surface temperature, chlorophyll concentration, and migration data on the Ocean Tracks website to explore some of what makes the California coast such a popular ocean destination.

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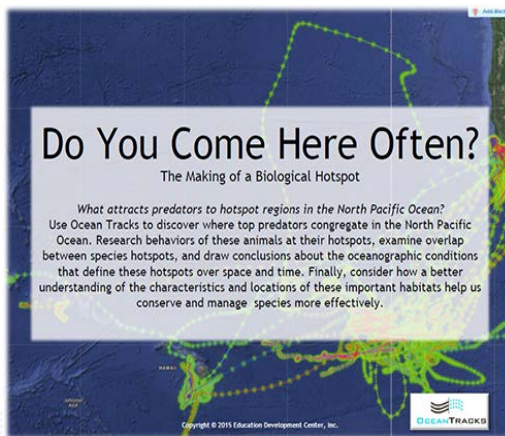


The Need for Speed

Exploring Adaptations for Migration

What adaptations make animals suited for long distance ocean travel? "Swim" along with elephant seals, bluefin tuna, Laysan albatrosses, and white sharks to find out who travels fastest, farthest, and deepest. Research the adaptations that make these animals suited for long distance ocean travel and how their migration tracks relate to known behaviors.

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Do You Come Here Often?

The Making of a Biological Hotspot

What attracts predators to hotspot regions in the North Pacific Ocean? Use Ocean Tracks to discover where top predators congregate in the North Pacific Ocean. Research behaviors of these animals at their hotspots, examine overlap between species hotspots, and draw conclusions about the oceanographic conditions that define these hotspots over space and time. Finally, consider how a better understanding of the characteristics and locations of these important habitats help us conserve and manage species more effectively.

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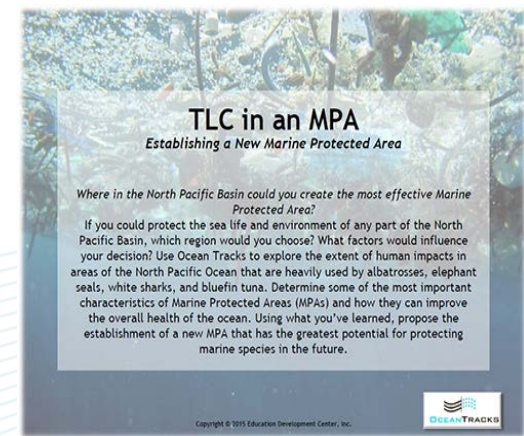

Battle of the Sexes

Determining the sex of elephant seal 302

Is Elephant Seal 302 male or female?

Some species exhibit physical and behavioral differences between the sexes. Use migration track points, measurements, and background information about elephant seal behaviors as clues to solve the mystery of whether Elephant Seal 302 is male or female. Defend your claim in a lively debate with your classmates. Determine who has the most sufficient evidence to knock out the competition in this "battle of the sexes."

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TLC in an MPA

Establishing a New Marine Protected Area

Where in the North Pacific Basin could you create the most effective Marine Protected Area?

If you could protect the sea life and environment of any part of the North Pacific Basin, which region would you choose? What factors would influence your decision? Use Ocean Tracks to explore the extent of human impacts in areas of the North Pacific Ocean that are heavily used by albatrosses, elephant seals, white sharks, and bluefin tuna. Determine some of the most important characteristics of Marine Protected Areas (MPAs) and how they can improve the overall health of the ocean. Using what you've learned, propose the establishment of a new MPA that has the greatest potential for protecting marine species in the future.

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OT-CE Data Skills

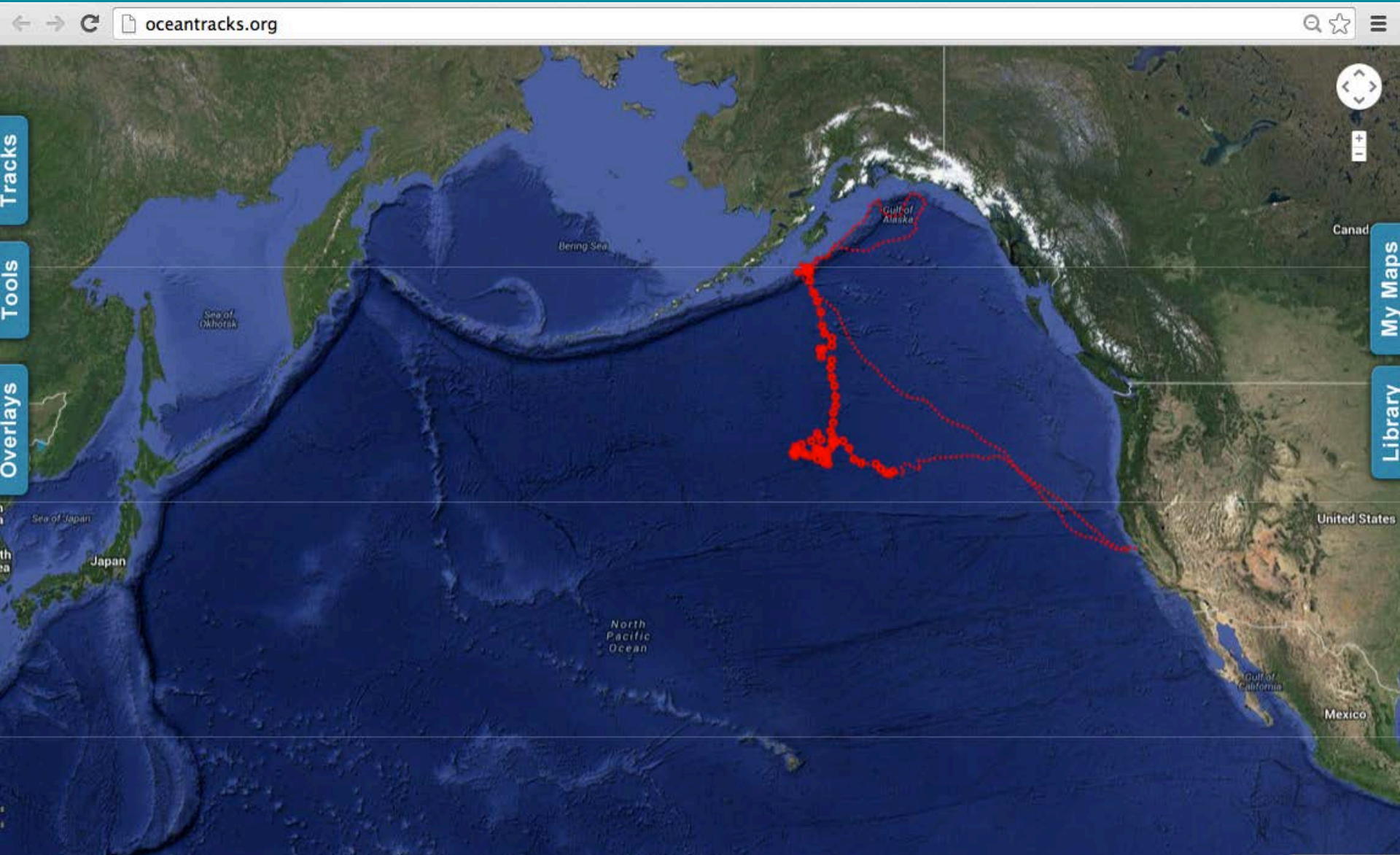
- Decoding and describing data patterns
- Explaining why a data pattern occurs using background info/content knowledge
- Providing appropriate or relevant data to support a claim or hypothesis
- Providing multiple sources of evidence to support a claim or hypothesis
- Providing reasoning for how data measurements or patterns support a hypothesis or claim, referring to scientific principles or processes
- Generating a hypothesis or claim that addresses a given research question

Goals for students

Explore questions of current scientific interest using compelling data sets.

- 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

The screenshot shows the oceantracks.org website interface. At the top, a browser address bar displays "oceantracks.org". The main content is a satellite map of the North Pacific Ocean, featuring a prominent red track line that starts in the Gulf of Alaska, moves south along the coast, and then loops back north. A "Track Species" menu is open on the left, listing "Laysan Albatross", "Bluefin Tuna", "Elephant Seal", "White Shark", and "Drifter Buoys". A "Use Unique Colors" checkbox is checked. Other interface elements include a "Tracks" label, an "Overlays" menu, and navigation controls like a search icon, a star, and a compass. The map labels include "Bering Sea", "Gulf of Alaska", "North Pacific Ocean", "Sea of Japan", "Japan", "United States", "Mexico", and "Gulf of California".

Track Species

- Use Unique Colors
- Laysan Albatross
- Bluefin Tuna
- Elephant Seal
- White Shark
- Drifter Buoys

Tracks

Overlays

My Maps

Library

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Get students quickly to the data

oceantracks.org

Track Species

Use Unique Colors

Laysan Albatross

Bluefin Tuna

Elephant Seal

Track ID (Year)	Show	Active
#302 (2005)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
#516 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#528 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#536 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#541 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#546 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#771 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#781 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#788 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#975 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#981 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#1159 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#1266 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#1271 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#1275 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#1278 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Show / Hide All	<input checked="" type="checkbox"/>	

White Shark

Track ID (Year)	Show	Active
#005 (2005)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#501600 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#501900 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#502000 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#502800 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#600100 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#600200 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#600800 (2006)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#602500 (2007)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
#702000 (2008)	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Tracks

Canada

United States

Mexico

Bering Sea

Gulf of Alaska

North Pacific Ocean

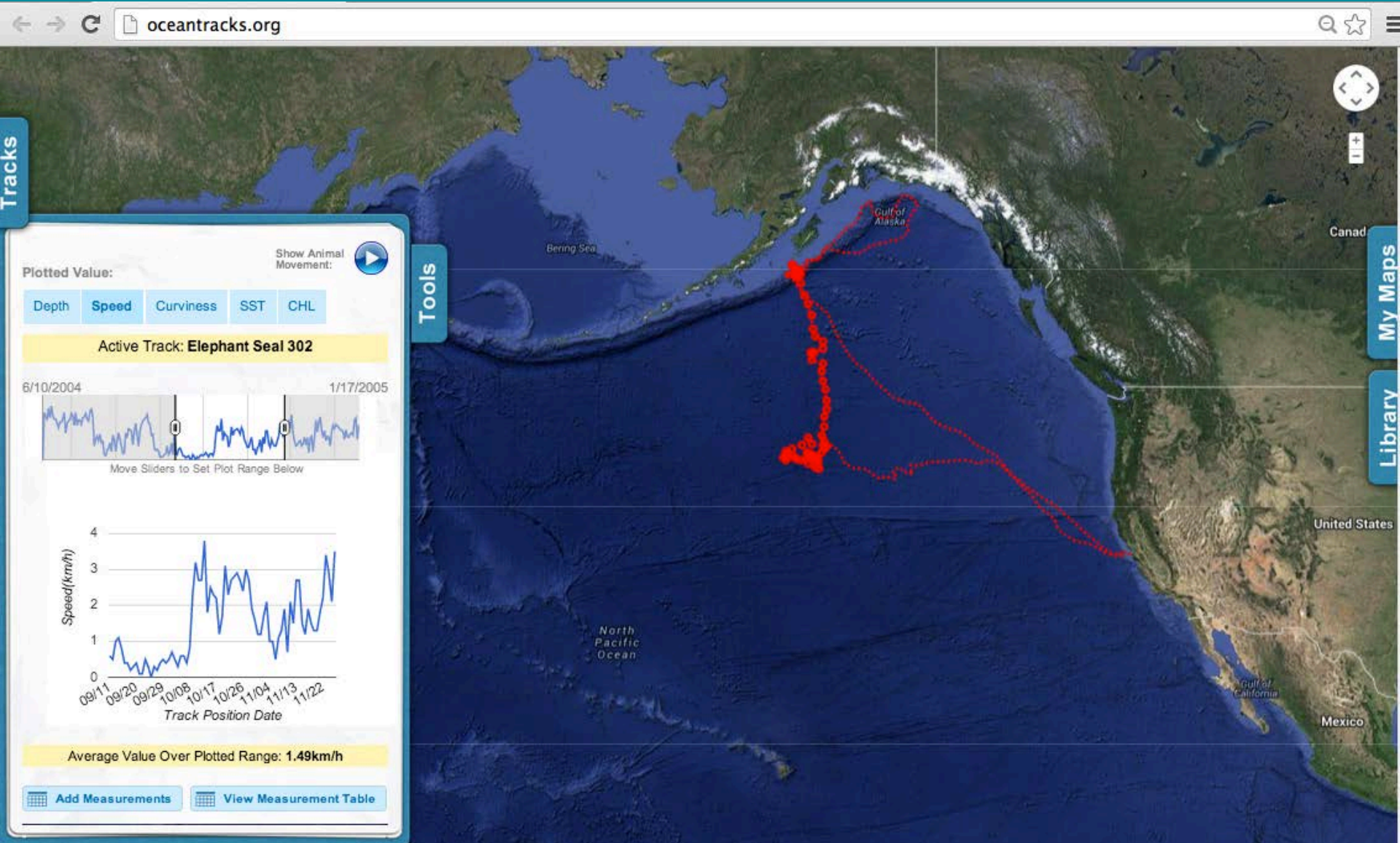
Gulf of California

My Maps

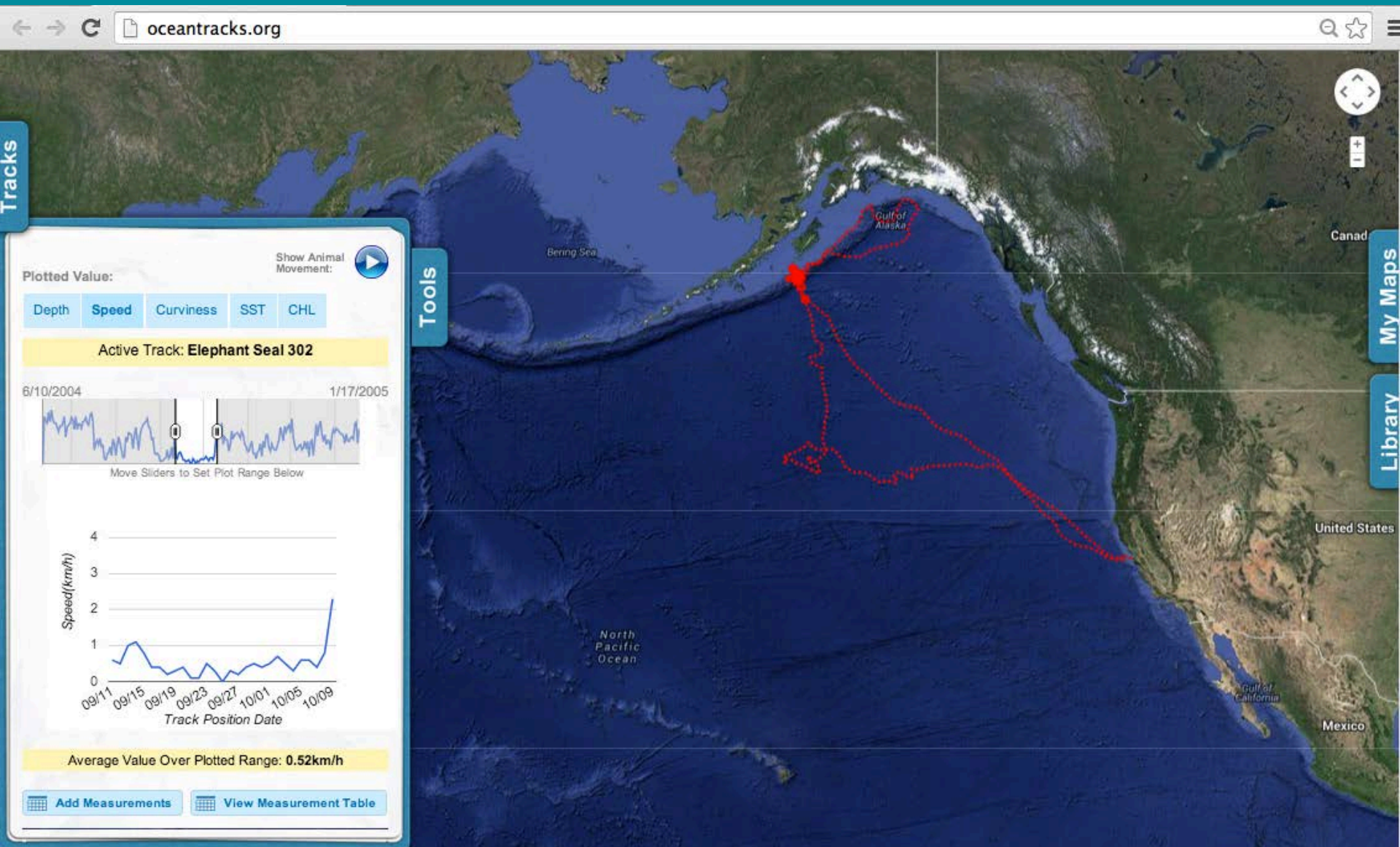
Library

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Allow them to easily create and interact with data displays



Allow them to easily create and interact with data displays



Allow them to easily create and interact with data displays

The screenshot shows the oceantracks.org website interface. The main map displays the North Pacific Ocean with a red dotted track for Elephant Seal 302. A 'Tools' panel on the left provides data visualization options and a speed plot. A 'Tools' popup window for Elephant Seal 302 is open, showing detailed tracking information.

Tools Panel:

- Plotted Value:
- Show Animal Movement:
- Speed (selected), Curviness, SST, CHL
- Active Track: **Elephant Seal 302**
- 6/10/2004 to 1/17/2005
- Speed(km/h) vs Track Position Date graph
- Average Value Over Plotted Range: **0.52km/h**
- Buttons: Add Measurements, View Measurement Table

Elephant Seal 302 Popup:

- Date: 10/10/2004 (Day 122 of 221)
- Day's Speed: 3.2 km/h
- Day's Curviness: 1.1
- Day's SST: 10.3 C
- Day's CHL: Not Available mg/m³
- Buttons: Show SST Map, Show CHL Map, Show Currents Map, Set Plot Start Date

Allow them to easily create and interact with data displays

oceantracks.org

Elephant Seal 302

Date: 10/10/2004
Day 122 of 221

Day's Speed: 3.2 km/h
Day's Curviness: 1.1
Day's SST: 10.3 C
Day's CHL: Not Available mg/m³

Show SST Map
Show CHL Map
Show Currents Map

Set Plot Start Date

1 Select Map Overlays

Bathy SST CHL Human Imp

2 Select a Year & Month for SST, Chlorophyl, or Currents

Year: 02 03 04 05 06 07 08 09 10 11 12

Month: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

3 Add Additional Layers

Show Currents Hotspot Map

Overlays

Tracks

Tools

My Maps

Library

United States

Mexico

Canada

Sea of Okhotsk

Provide supports that can be accessed on-demand

The image shows a screenshot of a web-based interface for marine data visualization. The main map displays the North Pacific Ocean, with labels for the Bering Sea, Gulf of Alaska, and North Pacific Ocean. A red dotted track with circular markers is overlaid on the map, starting from the Gulf of Alaska and extending southward. On the left side, there are three vertical menu buttons: 'Tracks', 'Tools', and 'Overlays'. On the right side, there is a 'Library' panel with a list of categories and a search icon. The 'Library' panel includes the following items:

- About
- + Species
- + Oceanographic Factors
- + Tags
- + The North Pacific Ocean
- + General Ecology
- Curviness Tool
- + Hotspots
- + Human Impacts
- + Marine Protected Areas
- Drifters
- + Video Tutorials

At the bottom of the interface, there is a copyright notice: 'Copyright © 2016 by Education Development Center, Inc. All rights reserved'. Below this, there is a small Google logo and a footer containing map data information: 'Map data ©2014 INEGI, SK planet, ZENRIN Imagery ©2014 NASA, TerraMetrics | 500 km | Terms of Use'.

Implementation Research Questions

- How do students and faculty at different undergraduate institutions engage in and interact with OT-CE?
- What changes in science attitudes and interests do students show after completing OT-CE modules?
- What changes in data inquiry skills do students show after completing OT-CE modules?
- How might changes in students' science attitudes and interests and data inquiry skills be related to the ways in which faculty implement OT-CE modules?

For more info, visit us at:

oceansofdata.org

Discussion

Why do you think it's important to teach with data?

How do you incorporate data into your teaching?