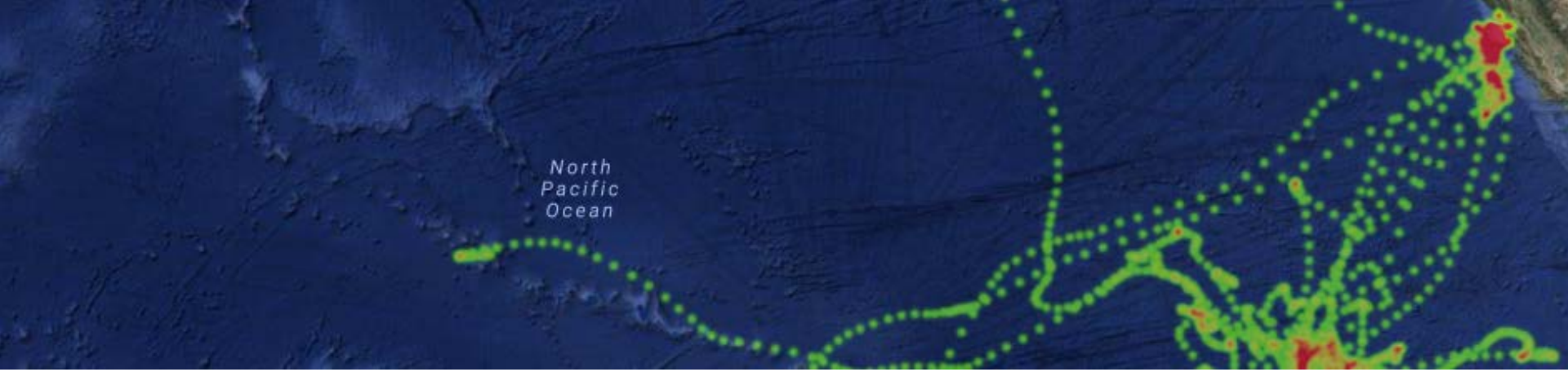


Do You Come Here Often?

The Making of Biological Hotspots

In this module, you will discover where and why top predators congregate in the North Pacific Ocean.

Learning Objectives

- Identify and describe features in animal tracking data that signify biological hotspots
- Make an evidence-supported claim about animal behavior(s) associated with a given biological hotspot using tracking data and oceanographic conditions
- Effectively communicate interpretations of data through a visual report or scientific poster

OCEANTRACKS

Pre-Lab Assignment

DEFINING HOTSPOTS

What makes a hotspot a "hot" spot? The term hotspot can mean a lot of different things. In geology, a hotspot is a place where volcanoes form. In society, a hotspot can be an area of political, military, or civil unrest or the trendiest nightclub in town. In the tech world, a hotspot is where you can connect your favorite electronic device to a wireless internet connection. Any way you slice it, though, a hotspot is essentially a place of high interest, activity, or popularity. The same is true in the ocean.

Consider the kinds of hotspots you might find in the ocean: hotspots visited by a single species and those used by multiple species.

Two Types of Biological Hotspots in Ocean Tracks

1. **Species hotspots** are areas that are used by many individuals of the same species. These areas are important to one particular species but may or may not have high biological diversity.
2. **Biodiversity hotspots** are areas that are used by many different species. In other words, these areas have high biological diversity.

Pre-Lab Assignment

PRE-LAB QUESTIONS

1. *Imagine that every student in your school was wearing a device that tracked their daily movements over the course of a semester. Consider every major (e.g., biology, philosophy, education) to be its own "species":*

   a. *Describe where on campus you would expect to find* species *hotspots (places where tracks of students with the same major frequently overlap). Explain what you think students might be doing in these locations.*

   b. *Describe where on campus you expect to find* biodiversity *hotspots (places where the tracks of all majors frequently overlap). Explain what you think students might be doing in these locations.*

   c. *Describe the tracking-data evidence you would use to identify how a hotspot is used. How would you expect tracking data* ***inside*** *the hotspot to compare with data* ***outside*** *the hotspot? Identify any additional information that would further support your claim about how the hotspot is used.*

(CONTINUED ON NEXT SLIDE)

Pre-Lab Assignment

PRE-LAB QUESTIONS (CONTINUED)

Now think about animals in the ocean, where they go, and what they might be doing inside their species hotspots.

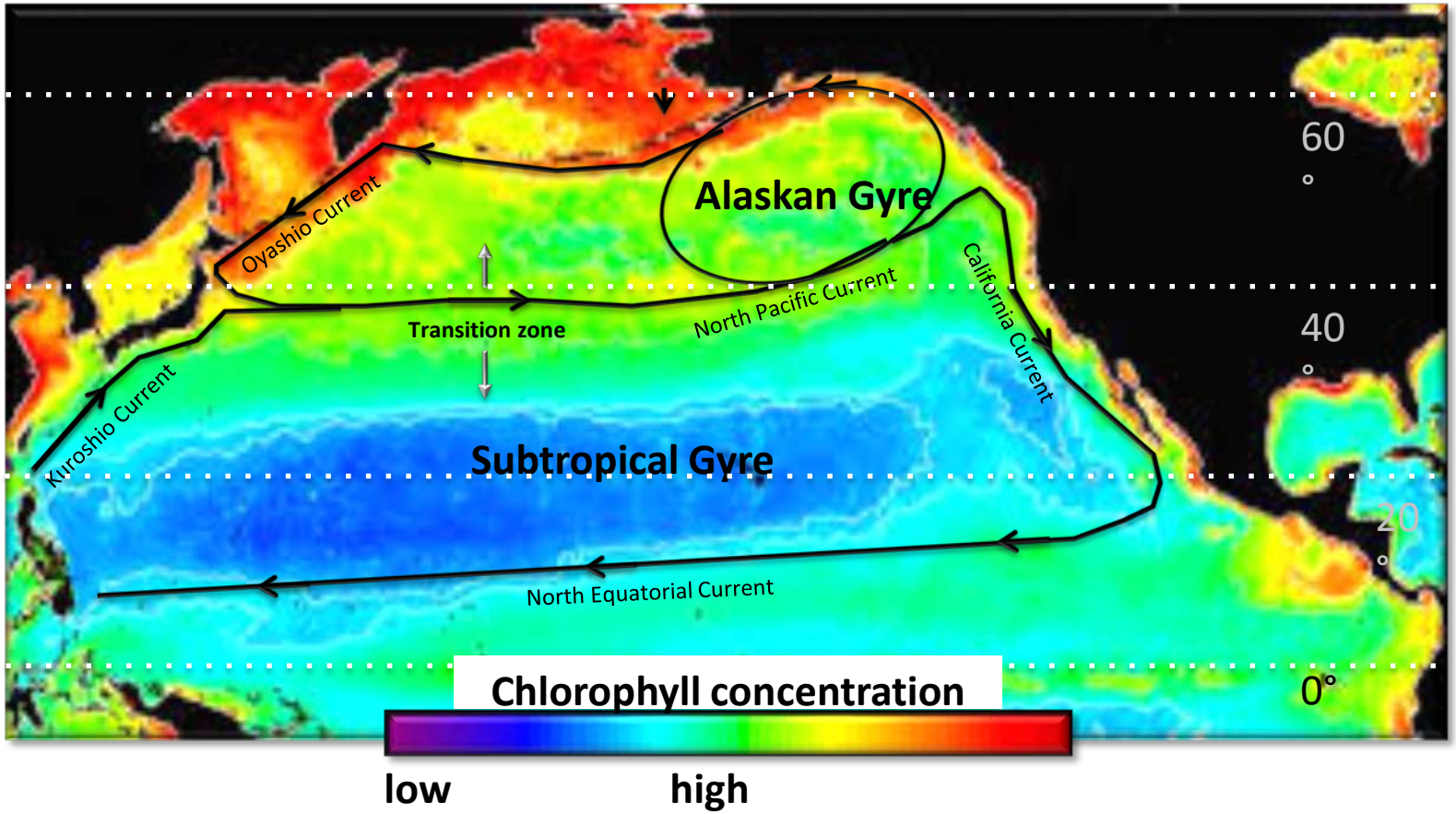
Just as campus hotspots—classrooms, dorms, the student union, etc.—have certain features that make them frequently visited by students, there are also certain features of the ocean environment that attract marine animals and support various behaviors.

You can see some of these in FIGURE 1 on Slide 5, which shows major circulation features in the North Pacific overlaid on annually averaged chlorophyll concentration (CHL). To help you recognize the features that would be important to marine life, consult the Ocean Currents (http://oceantracks.org/library/oceanographic-factors/ocean-currents/) and Chlorophyll pages (http://oceantracks.org/library/oceanographic-factors/chlorophyll/) of the Ocean Tracks Library.

2. *Based on your understanding of these features, describe where you would expect to find species hotspots and why.*

Pre-Lab Assignment

FIGURE 1. Major circulation features overlaid on annually averaged surface chlorophyll concentration in the North Pacific Ocean



Engage

SPECIES HOTSPOTS AND HOTSPOT MAP TOOL

Recall from the Pre-Lab Assignment that species hotspots are areas that are used by many individuals of the same species. Let's look at an example of how to identify species hotspots in the Ocean Tracks interface.

Figure 2 shows all of the elephant seal tracks available in Ocean Tracks, with polygons drawn around areas where multiple tracks converge or overlap. (NOTE: Use Unique Colors is turned on to make it easier to distinguish individual tracks.)

Although visual inspection is a good first step, technology can help us confirm that the features we see with our eyes are mathematically significant.

Ocean Tracks has a Hotspot Map tool (#3 in the Overlays menu) that measures the density of points in a particular area. The higher the density of points, the more red the area appears. The lower the density of points, the more green the area appears. Learn more about the Hotspot Map tool here: http://oceantracks.org/library/the-hotspot-tool/

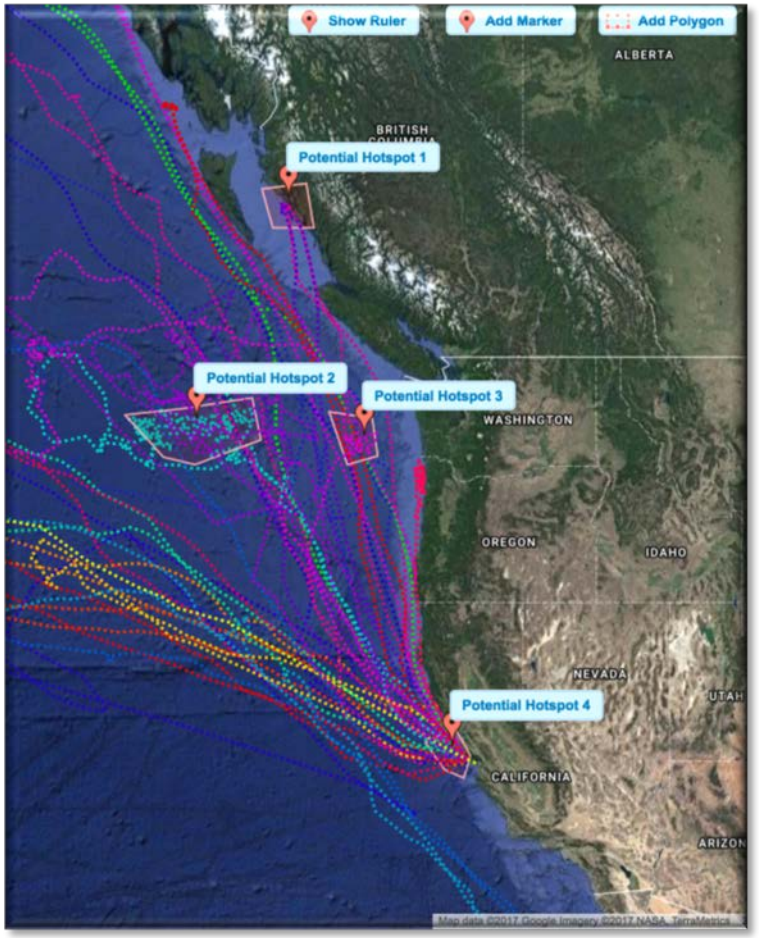


Figure 2. Elephant seal tracks showing areas of overlap outlined with Polygon tool

Engage

Figure 3 below shows how the **Hotspot Map** tool displays different densities of track points (i.e., the relative number of track points packed into a given area).

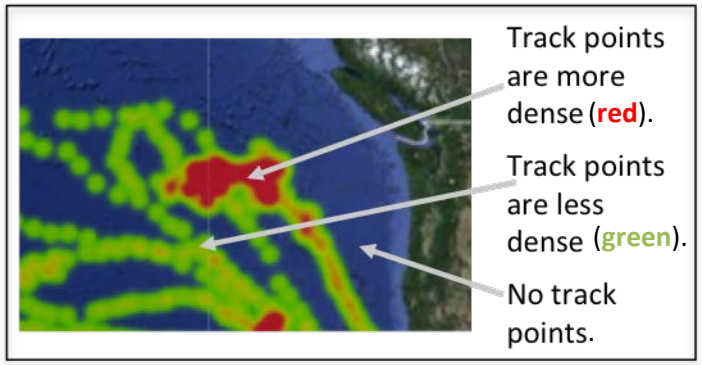


Figure 3. The Ocean Tracks Hotspot Map tool measures the density of points in a particular area

Figure 4 shows the same map as Figure 2 but with the **Hotspot Map** layer turned on and the seal tracks hidden to make it easier to identify areas of high track-point density.

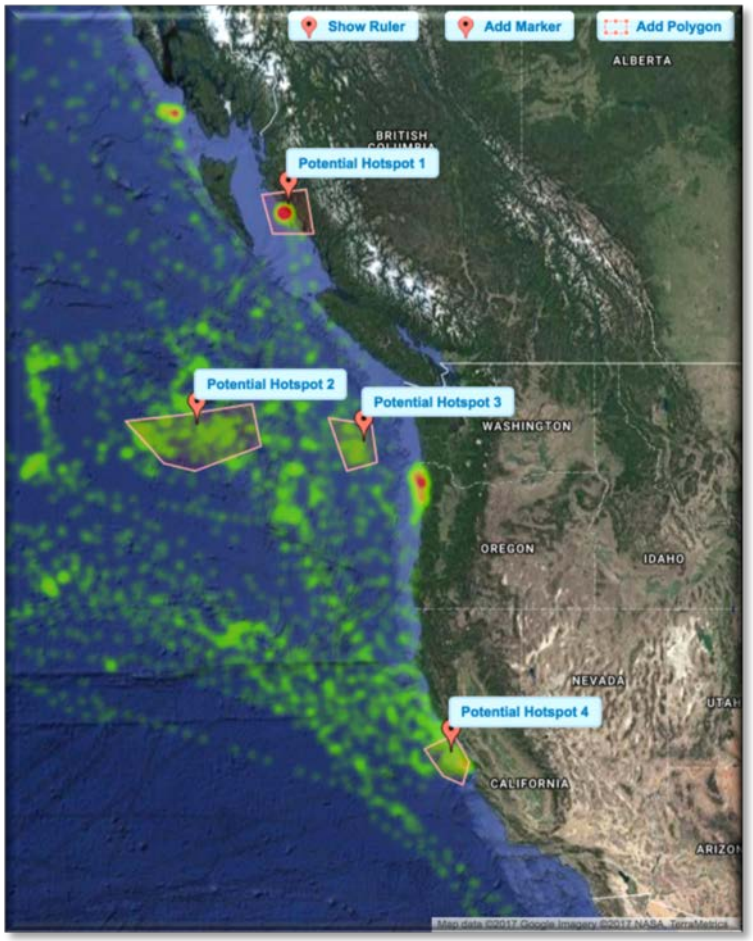


Figure 4. Elephant seal tracks showing Hotspot Map overlay and tracks hidden

Engage

CLASS DISCUSSION

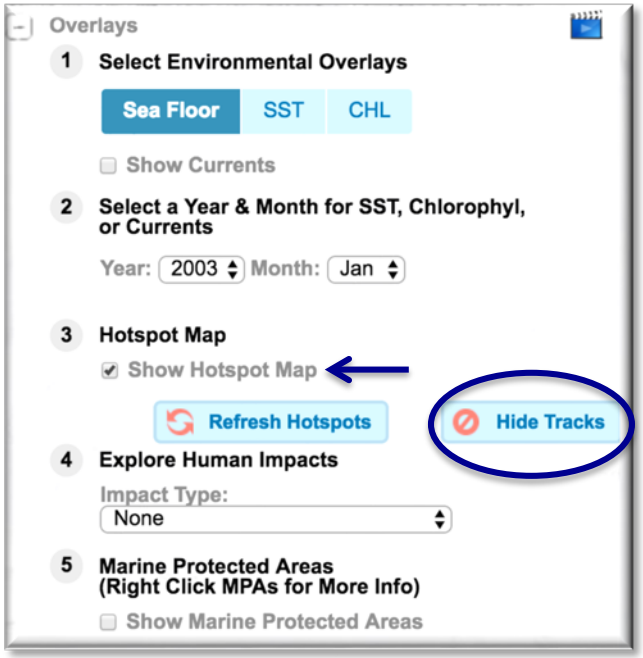
As a class, discuss the following:

1. *Look at Figure 2 on Slide 6. Go to http://oceantracks.org/map and **Show All** elephant seal tracks to get a closer look. Why do you think elephant seals might be spending more time in some areas of the ocean than others?*

2. *Look at Figure 4 on Slide 7. In Ocean Tracks, turn on the **Hotspot Map** tool:*
   - *Click the **+** to expand **Overlays** in the **Data & Tools** tab.*
   - *Check the **Show Hotspot Map** box to turn on the **Hotspot Map** tool.*
   - *Click **Hide Tracks**.*

   Do any of the areas of high track-point concentration align with ocean circulation or chlorophyll concentration features shown on Slide 5? Brainstorm some reasons why or why not.

3. *Compare Figures 2 and 4. How well did the two methods of hotspot identification (visual inspection and using the Hotspot Map tool) agree? In other words, did both methods yield the same results or were there differences? Discuss potential causes of any differences you found.* **HINT:** Think about how the Hotspot Map tool works



(CONTINUED ON NEXT SLIDE)

Engage

CLASS DISCUSSION (CONTINUED)

4. *How might you figure out what the elephant seals do inside each of these potential hotspots? As an example, assume that one of the hotspots is used for feeding.*

   a. *Which Ocean Tracks data set(s) (average daily speed, deepest daily dive, curviness, SST, CHL) could be used to look for evidence of known feeding behaviors? (If needed, use the Ocean Tracks Library to learn more about typical feeding behaviors of elephant seals: http://oceantracks.org/library/species/elephant-seal.)*

   b. *What patterns would you look for in those data as evidence of feeding behaviors? How would you expect data values **inside** a feeding hotspot to look different from data values **outside** that hotspot?*

Explore

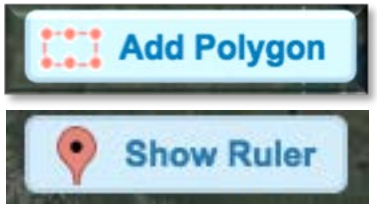
PART 1: MAKING TRACKS

Now it's your turn to identify hotspots and explore the data in Ocean Tracks for bluefin tuna OR white sharks—the choice is yours—to try to understand why animals spend so much time in these locations.

- Go to http://oceantracks.org/map.
- Examine all of the bluefin tuna OR white shark tracks to identify potential species hotspots by determining where multiple tracks overlap. Follow these instructions:
    - Click on the Data & Tools tab to access the Tracks menu.
    - Click the + to expand the Tracks list and then click + again to expand the list of bluefin tuna OR white shark tracks.
    - Check the Show/Hide All box at the bottom of the list to show all tracks. Make sure all other tracks are turned off.
    - Check the **Use Unique Colors** box at the top of the tab to make it easier to distinguish individual tracks.
    - Carefully examine the map to identify potential hotspots (areas where multiple tracks come together or overlap) for the species you have chosen.

Explore

- Use the **Add Polygon** tool to draw a box around one of these areas that contains ***at least four different tracks***.
- Use the **Show Ruler** tool to measure the approximate dimensions of your polygon.



EXPLORE PART 1 QUESTIONS

1. *Describe your hotspot in enough detail that someone who was not looking at the map would be able to visualize it in their mind. Include the following information in your description:*
   - *The species you chose, the number of different animals that have track points inside your polygon, and the tracking ID for each of those animals.*
   - *Shape or other distinctive features of tracks inside the hotspot.*
   - *Geographic location: Use landmarks and/or state and town names and distances from them as reference points if possible.*
   - *Area: Use your ruler measurements to calculate an area for your hotspot in km^2.*
   - *Screenshot of the map showing your hotspot polygon (See http://www.take-a-screenshot.org/ for instructions on how to take a screenshot.)*

Explore

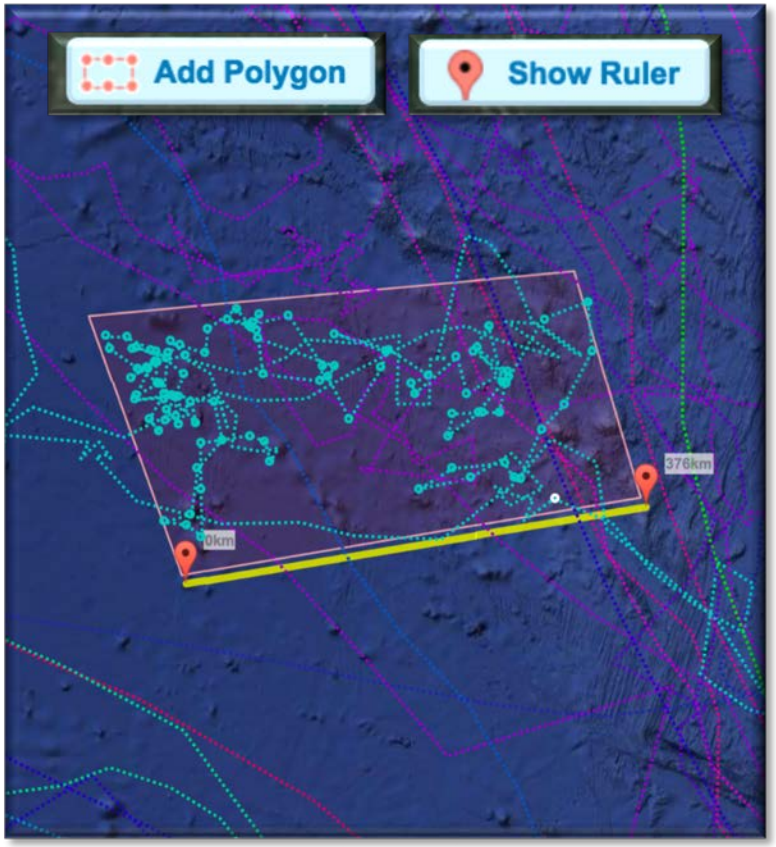


Figure 5. Screenshots showing elephant seal hotspot polygon and measurement

Explore

PART 2: WHY SO "HOT"?

Now, take a look at other data available in the Ocean Tracks interface that can help you determine what animals might be doing in the hotspot you have identified.

- Start by isolating a single track within your hotspot:
  - Click on a point along one of the tracks near the middle/highest track density of your hotspot polygon. Click the **Activate Track** button to **Graph** the track. (See Figure 6 on Slide 14.)
  - Scroll up to **Tracks** and check the **Show/Hide All** box for the species you are investigating to clear (hide) the tracks.
  - Show only the single track you identified above.
- Click the + to expand the **Tools** menu and explore the behavior of this individual within your hotspot polygon. To select the proper time interval:
  - Click on a data point near one of the polygon's boundary lines to begin determining the approximate time interval over which the animal is within the hotspot.
  - Under Tools, move the time sliders to display only the section of the track that is inside the hotspot. As you move the sliders, the highlighted track points on the map change accordingly. (See Figure 7 on Slide 15.)

Explore

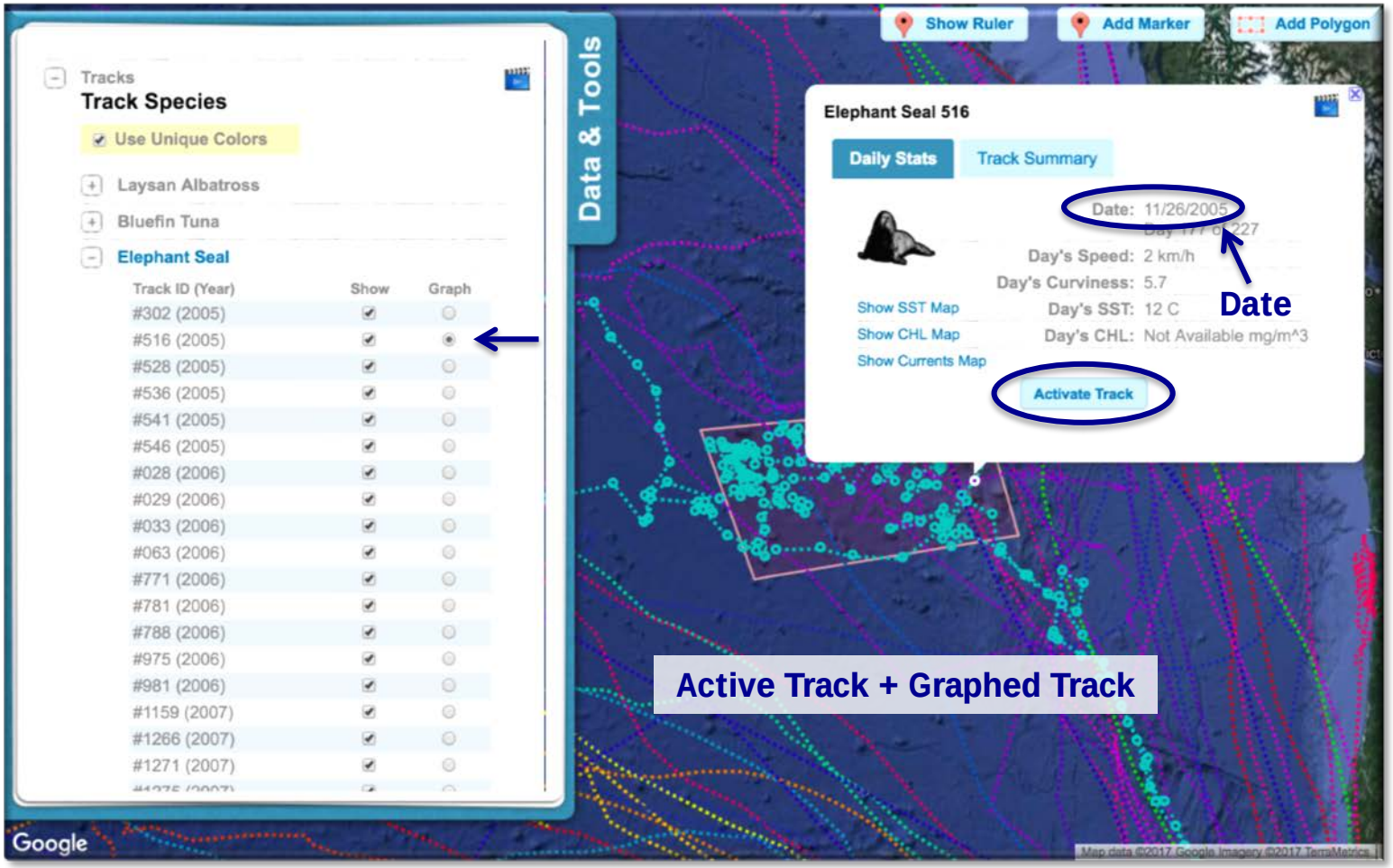


Figure 6. Screenshot showing how to activate a single track

Explore

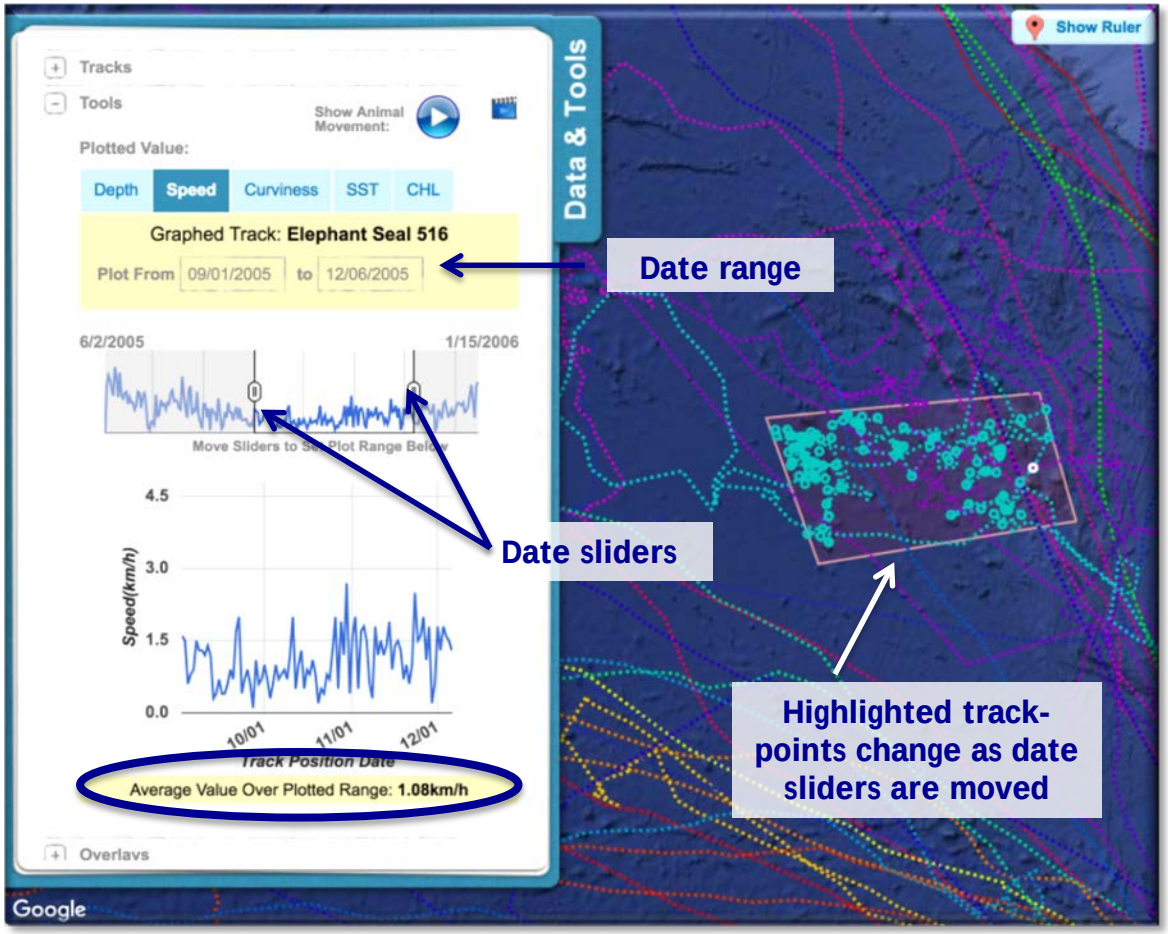


Figure 7. How to isolate track points inside a hotspot

Explore

Make two tables like the ones on Slide 18 (Table 1 and Table 2) and record measurements for this track both INSIDE and OUTSIDE the hotspot polygon. To do this:

- Record the dates during which this animal is inside the hotspot.
- Look at graphs for **Depth, Speed, Curviness, CHL,** and **SST** and record average values for each in your **INSIDE Hotspot table. NOTE:** If you are not familiar with the concept of **Curviness**, you can learn about it in the Ocean Tracks **Library** (http://oceantracks.org/library/the-curviness-tool/).
- Adjust the date sliders to highlight several (5-10) track points well outside the hotspot, but not within another hotspot. Record these dates in your **OUTSIDE Hotspot table**. Take a screenshot of the map showing your hotspot and highlighted track points outside the hotspot (See Figure 8 on Slide 17 for an example).
- Look at graphs for **Depth, Speed, Curviness, CHL,** and **SST** for this date range and record average values for each in your **OUTSIDE Hotspot table**.

Repeat the above steps to add measurements to both tables for **3 other individuals** of this species that have track points inside your hotspot.

Explore

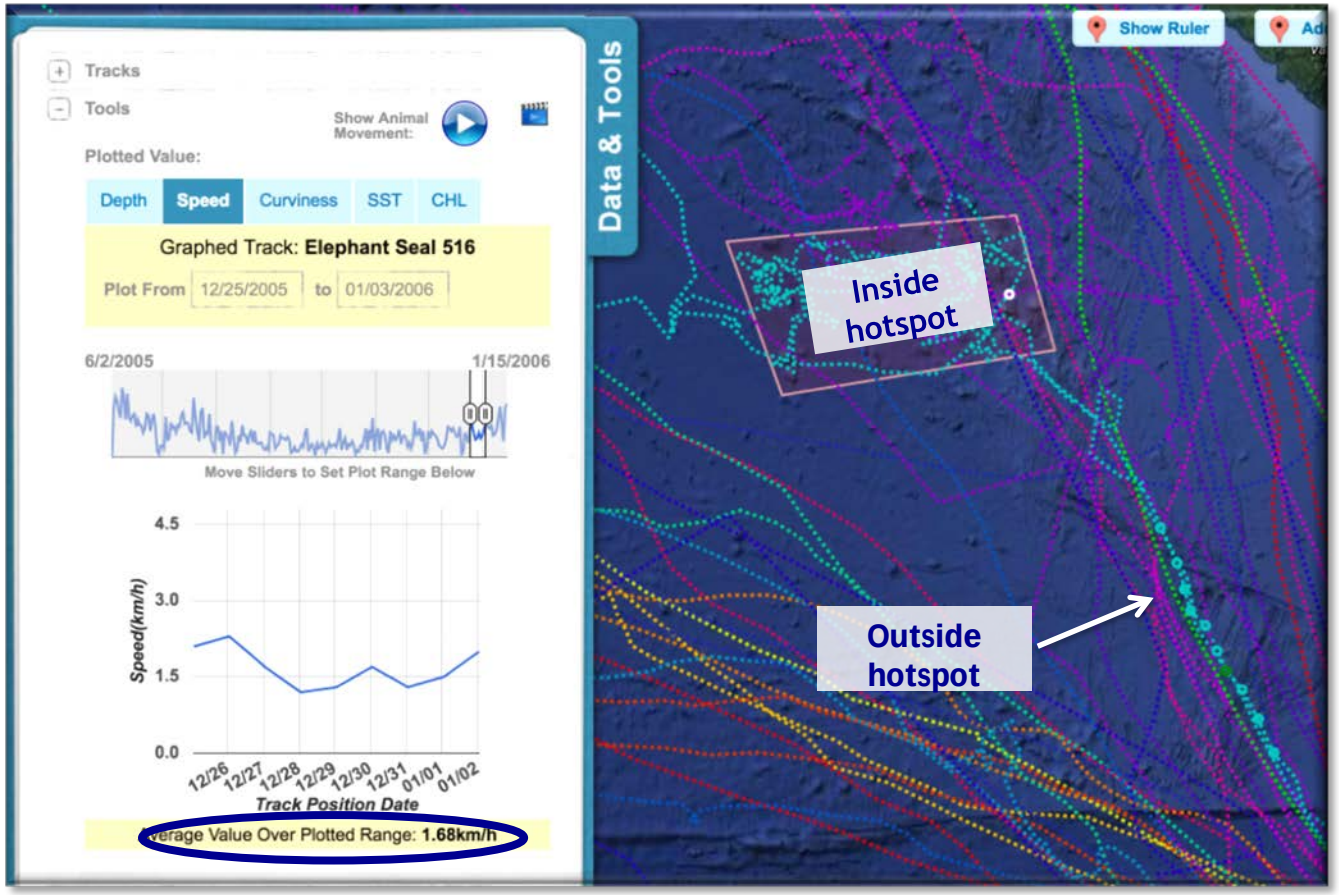


Figure 8. Example of track points <u>outside</u> a hotspot

Table 1. Tracking Data INSIDE Hotspot

Animal Species/ ID	Dates Inside Hotspot	Average Max. Daily Depth (m)	Average Speed (km/h)	Average Curviness	Average CHL (mg/m^3)	Average SST (°C)

Table 2. Tracking Data OUTSIDE Hotspot

Animal Species/ ID	Dates Outside Hotspot	Average Max. Daily Depth (m)	Average Speed (km/h)	Average Curviness	Average CHL (mg/m^3)	Average SST (°C)

Explore

EXPLORE PART 2 QUESTIONS

Collecting and organizing data can only take us so far in determining how these animals are using the hotspots. Some deeper analysis is needed to draw more-robust conclusions. Answer the following questions using the data in your tables to identify patterns that might provide clues about what animals are doing inside your chosen hotspot.

1. *How much time did each animal spend INSIDE the hotspot?*

    a. *Calculate the number of days each animal was inside the hotspot.*

    b. *Calculate the **median** (the middle number in an ordered list) time spent inside the hotspot for all four animals.* (**NOTE:** To calculate the median, put all four values from 1a in order and average the middle two.)

    c. *How do the values in part a compare to those in 1b? Which animals, if any, appear to be outliers (i.e., were in the hotspot for significantly more or less time than the median)? How might the outliers affect your interpretation of how these animals are using the hotspot?*

    d. *Compare the time of year each of these animals was inside the hotspot. Were multiple animals there during the same season? What can timing tell you about what animals might be doing in this hotspot?*

(CONTINUED ON NEXT SLIDE)

Explore

EXPLORE PART 2 QUESTIONS (CONTINUED)

2. *Answer the following questions using the data in your tables to identify patterns that might provide clues about what animals are doing inside your chosen hotspot.*

    a. *How does animal movement inside the hotspot compare to movement outside the hotspot?*

    b. *Calculate the median average maximum daily depth both INSIDE and OUTSIDE the hotspot. Is the median higher, lower, or similar inside the hotspot compared with outside the hotspot? Are there any outliers (individuals with an average maximum daily depth that is significantly higher or lower than the median inside the hotspot)? How might the outliers affect your interpretation of how these animals are using the hotspot?*

    c. *Calculate the median average speed both INSIDE and OUTSIDE the hotspot. Is the median average speed higher, lower, or similar inside the hotspot compared with outside the hotspot? Are there any outliers)? How might the outliers affect your interpretation of how these animals are using the hotspot?*

    d. *Calculate the median average curviness INSIDE and OUTSIDE the hotspot. Is the median average curviness higher, lower, or similar inside the hotspot compared with outside the hotspot? Are there any outliers? How might the outliers affect your interpretation of how these animals are using the hotspot?*

(CONTINUED ON NEXT SLIDE)

Explore

EXPLORE PART 2 QUESTIONS (CONTINUED)

Answer the following questions using the data in your tables to identify patterns that might provide clues about what animals are doing inside your chosen hotspot.

3. *How do the oceanographic conditions INSIDE the hotspot compare to those OUTSIDE the hotspot?*

    a. *Calculate the **median** average **SST** both INSIDE and OUTSIDE the hotspot. How do the values compare? (For more information about SST and how these values can be used to indicate productivity, go to the Ocean Tracks Library: http://oceantracks.org/library/oceanographic-factors/sea-surface-temperature/)*

    b. *Calculate the **median** average **CHL** both INSIDE and OUTSIDE the hotspot. How do the values compare? (For more information about CHL and how these values can be used to indicate productivity, go to the Ocean Tracks Library: http://oceantracks.org/library/oceanographic-factors/chlorophyll/)*

    c. *Does your hotspot overlap any of the circulation or chlorophyll concentration features shown on Slide 5? Explain what that means with respect to how animals might be using this hotspot.*

(CONTINUED ON NEXT SLIDE)

Explore

EXPLORE PART 2 QUESTIONS (CONTINUED)

4. *Make a claim: Based on the data you recorded in Table 1 (Tracking Data INSIDE Hotspot) and Table 2 (Tracking Data OUTSIDE Hotspot), and the calculations and analyses performed above, what conclusion have you come to about how this species uses this hotspot? Is it used for feeding, breeding, transiting, or something else?*

5. *What patterns in the data led you to make this claim? Do all of the animals in your hotspot seem to be using it the same way (i.e., Do all or only some of the animals with track points inside the hotspot exhibit the same data patterns)? Explain.*

Synthesize

PART 1: GATHER MORE INFORMATION

In this section, you will communicate your findings through a visual report (e.g., PowerPoint) or scientific poster. Before you get started, read one of the journal articles below to learn more of what scientists know about your chosen species and how it uses different areas of the ocean. Use (and cite) information in the paper to help refine or support your claim about the hotspot you investigated.

Read the paper below that corresponds to the species you investigated. As you read, note the higher-resolution data collection (i.e., more tracks) and different analysis techniques used by the researchers as compared to the data available in the Ocean Tracks interface.

- ***Bluefin tuna:*** Boustani, A. M., Matteson, R., Castleton, M., Farwell, C., & Block, B. (2010). Movements of Pacific bluefin tuna (Thunnus orientalis) in the Eastern North Pacific revealed with archival tags. Progress in Oceanography, 86, 94–104. http://tinyurl.com/jtbn3d9
- ***White sharks:*** Jorgensen, S. J., Arnoldi, N. S., Estess, E. E., Chapple, T. K., Rückert, M., Anderson, S. D., & Block, B. A. (2012). Eating or meeting? Cluster analysis reveals intricacies of white shark (Carcharodon carcharias) migration and offshore behavior. PloS one, 7(10), e47819. http://tinyurl.com/hyd9rnh

Synthesize

PART 2: ASSEMBLE YOUR REPORT OR POSTER

Effective communication is an important part of the scientific process. Presenting scientific work to others is more than just sharing information—it's about providing your audience with a clear, easy-to-understand interpretation of data. In other words, your visual report or poster shouldn't just tell others what you found. It should tell them what your findings mean.

Share the most relevant data, observations, and analyses from your work on the Explore section of this module in the form of a visual report or scientific poster. As you prepare, keep your audience in mind, try to see things from their perspective, and ask yourself the following questions:

- What are the most important/interesting findings from my research project? What do they mean?
- How can I visually share my results and interpretations with my classmates in a clear, concise way? How should I use data tables, graphs, and images?

Your visual report or poster should include the following sections (See details and examples on Slides 25–32):

- Title and Overview
- Results
- Discussion: Claim, Evidence and Reasoning, Outstanding Questions

Synthesize: Visual Report

Title

Your Name, Institution

Provide a brief overview (one paragraph) of your hotspot investigation that includes the following:

- *Which species you chose and why*
- *The methods and tools you used to identify and choose a hotspot to investigate*
- *A description of your hotspot that includes location, size, and the number of animals that have track points within the boundaries of the hotspot*

Synthesize: Visual Report

Results ←

What did you find out? Use more than one slide with the Results title so as not to clutter your slides. Each slide should have only one main point/takeaway to focus your audience's attention on some piece of what you found during your investigation. This section should NOT include any interpretation of what the results mean.

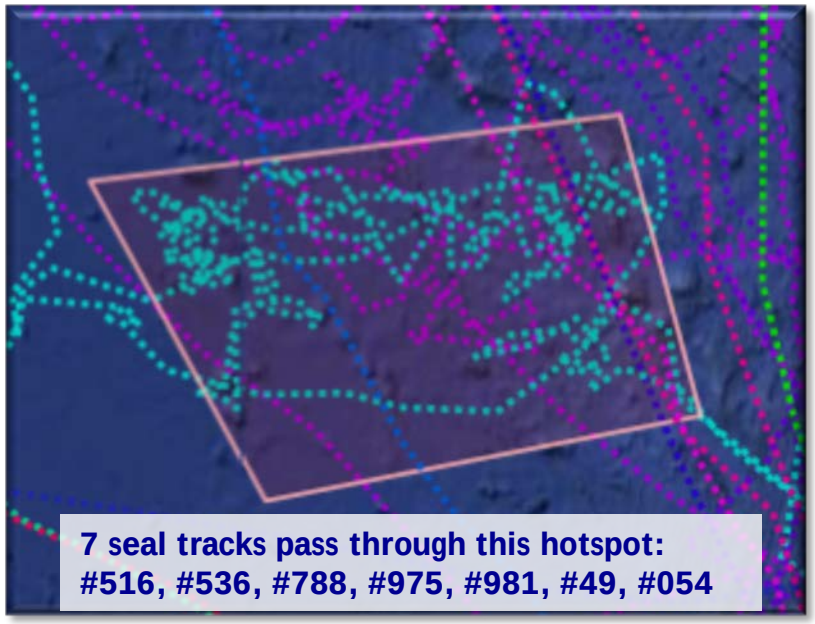
Your Results slides should include the following:

- A clear message statement of the result/data being presented on each slide. For example: Tracking Data & Environmental Conditions INSIDE Elephant Seal Hotspot
- One or more screenshots of your species hotspot (which may have been captured in the **Explore** section), **with annotations** to focus readers' attention on key features. (See Slide 27 for examples.) In particular, you should include the following annotations:
  - Number of different tracks inside the hotspot
  - Area of hotspot in km^2
  - Which track points you considered to be inside *and* outside the hotspot for your analysis
- Your INSIDE Hotspot and OUTSIDE Hotspot data tables, **with annotations** that show your audience how to read the data or where to focus their attention. Consider adding columns to your data tables for calculations from Explore Part 2 that are most relevant to your claim about **how the hotspot is used.**

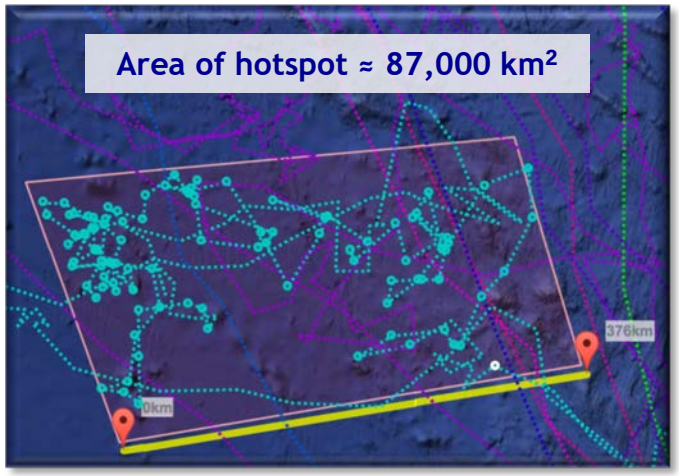
Synthesize: Visual Report

EXAMPLE RESULTS

Example 1

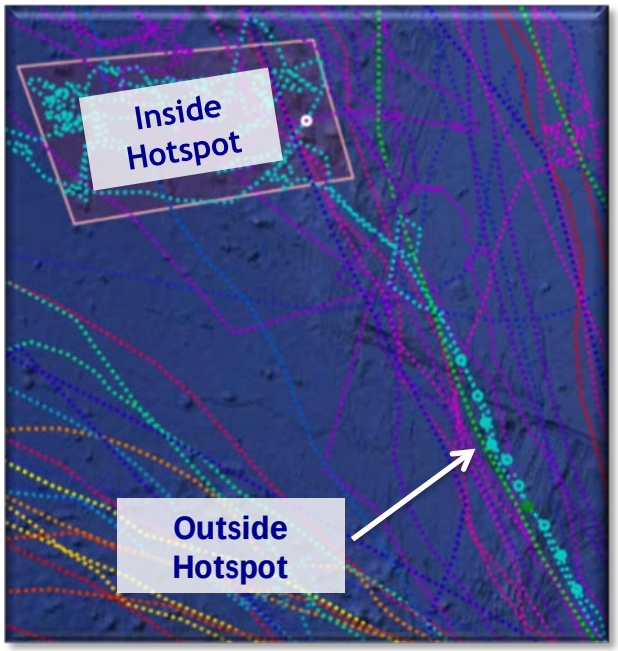


Example 2



Synthesize: Visual Report

Example 3



EXAMPLE RESULTS

Faster avg. speed indicates transiting; lower avg. speed indicates lingering

Curviness close to 1 means straight path

Example 4

Table 1. INSIDE Hotspot

Animal Species / ID	Dates Inside Hotspot	Avg. Depth (m)	Avg. Speed (km/h)	Avg. Curviness	Avg. SST (°C)	Avg. CHL (mg/m³)
#516	08/10/2005-12/12/2005	-563.03	1.09	4.75	14.04	0.18
#536	07/02/2005-07/04/2005	-551.0	5.0	1.0	12.5	0.3

Synthesize: Visual Report

Discussion

What do your results mean? This section of your presentation should focus on interpreting your results in the context of what was already known, and to explain new understandings. Use multiple slides to avoid clutter and focus your audience on one takeaway at a time.

CLAIM

Include your claim (from Explore Part 2, question 4) as a headline "message statement" about how you interpreted your data. Based on the data you recorded in Table 1, INSIDE Hotspot, and Table 2, OUTSIDE Hotspot, and the calculations and analyses performed in Explore Part 2, what conclusion did you come to about how this species uses this hotspot? Is it used for feeding, breeding, transiting, or something else?

EVIDENCE + REASONING

All claims must be supported by appropriate and sufficient evidence. However, even a strong claim may not be completely supported by the data you collected. When communicating scientific results, it is important to share both evidence for and against a claim as well as why the evidence that supports your claim is stronger than the evidence against it.

(CONTINUED ON NEXT SLIDE)

Synthesize: Visual Report

Include the following evidence and reasoning in your report, using values from your data tables, information from the Ocean Tracks Library (http://oceantracks.org/library/), screenshots of maps and/or graphs with annotations, etc. (see example on Slide 31):

- At least two pieces of evidence that most strongly support your claim about how this species uses the hotspot you chose and explanations to justify why the evidence supports your claim
- One piece of evidence that does not clearly support your claim, but is still relevant to understanding what function this hotspot serves for your species and an explanation to justify why the evidence does not support your claim.

OUTSTANDING QUESTIONS

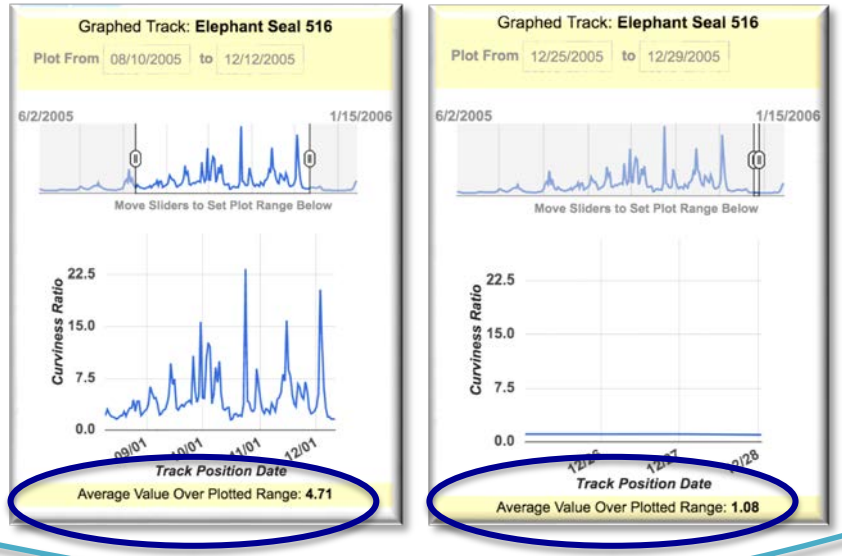
- What is already known about this species and how it uses different parts of the ocean? (Include appropriate citations.)
- What questions do you still have about this hotspot?
- What additional information or other kinds of data would help strengthen your claim? Why?

Synthesize: Visual Report

The example below is to provide some guidance on how to present evidence to support your claim.
This example is for one piece of evidence only; you should incorporate as many pieces of evidence as you can to support your claim. The more evidence you can provide, the stronger your claim will be.

Example Claim: The Elephant Seal hotspot I studied is used for feeding.

Example Evidence that supports the claim: The average curviness of Track #516 is 4.75 inside the Hotspot, which is more than 4 times the Curviness outside the hotspot (1.00).



Example Explanation:

According to the Ocean Tracks Library, the closer the curviness number is to 1, the straighter the animal is travelling. If the seal was transiting or traveling from one place to another, I would expect it to be following a relatively straight path, with a curviness close to 1. The high curviness inside the hotspot (4.75) means the seal track inside the hotspot was curvy or twisty, which could be an indication that the seal is foraging (searching for food).

Synthesize: Poster

Assemble data and observations from your work on the Explore section of this module in the form of a scientific poster (see basic template below). The goal of this poster is to display your findings in a clear, concise, and visually interesting manner.

Title

Author, Institution

OVERVIEW
Provide a brief overview (1 paragraph) of your hotspot investigation that includes:

- What species you chose and why
- The methods and tools you used to identify and choose a hotspot to investigate
- A description of your hotspot that includes location, size, and the number of animas that have tracks points within the boundaries you defined for the hotspot

RESULTS
What did you find out? Use more than one slide with the Results title so as not to clutter your slides. Each slide should have only one main point/takeaway to focus your audience's attention on some piece of what you found during your investigation. This section should NOT include any interpretation of what the results mean.
(See Slides 23-25 for additional details and examples.)

DISCUSSION
What do your results mean? This section of your presentation should focus on interpreting your results in the context of what was already known, and to explain new understandings. Use multiple slides to avoid clutter and focus your audience on one takeaway at a time. (See Slides 29-31 for additional details and examples.)